4. MODERN NON-FEDERAL DREDGE-AND-FILL ACTIVITIES IN GALVESTON BAY

There is a considerable range of dredge-and-fill operations not carried out by the Corps of Engineers, but rather by private interests and public agencies. These include port approaches and dock facilities, marinas and boat slips, drilling and well installation, pipelines, canals and channels, bridges and shoreface structures, bulkheads, revetment, dikes and levees, borrow excavations, land filling and grade elevation, and outfall structures. These and related activities are regulated by the Corps of Engineers through the approval and issuance of permits. Actually, since federal agencies other than the Corps are also required to have a Corps-issued permit, this chapter should more properly be titled "Non-Corps Dredge-and-Fill Projects," but the amount of federal activity in Galveston Bay other than that of the Corps is negligible.

A multiplicity of legislative authority empowers the regulation by the Corps of dredging and filling, beginning with the 1899 Rivers and Harbors Act, and including most prominently the 1972 Federal Water Pollution Control Act Amendments (PL 92-500). Section 10 of the Rivers and Harbors Act (33 USC 403), Section 404 of the 1972 FWPCA and the 1977 Clean Water Act Amendments (33 USC 1344), and Section 103 of the 1972 Marine Protection, Research and Sanctuaries Act (33 USC 1413) together encompass virtually any type of displacement of sediment in an aquatic system such as Galveston Bay, i.e., its removal, transport or placement. The key process is Department of the Army (DOA) permitting (33 USC 325) (which subsumes and incorporates the older USCE Section 10 permitting as well as 404 and 103 permits). For projects regulated by Section 404, the permit is co-administered by the Corps and by the Environmental Protection Agency. The jargon has come to refer to these DOA permits as "404" permits, though the permitted activity may be subject to any one of Sections 10, 404 and 103. For simplicity, in this report these are called "404," "10/404," and "DOA" permits interchangeably. Of course, in the analyses, it is the actual permitted *activities* that are treated, so which legislative authority has jurisdiction is irrelevant.

The time history of DOA (Section 10/404) permitting is shown in Fig. 4-1, for the general region of Galveston Bay including all tributaries and inland operations. The broad trends in this permitting activity are indicated by the shaded lines on Fig. 4-1. After WW II, the rate of permit issuance rose to about 70 per year, which was maintained, more or less, from the late 1950's to the early 1970's. Then, the rate of permits rose precipitously to about 180/yr by 1976. This is indubitably a response to the new 404 requirements of FWPCA (PL 92-500), and the formalization of the 404 process, but also due to the vigorous economic expansion during this period. Beginning in the early 1980's the rate of permitting began to drop, ultimately by the late 1980's to a level on the order of that prior to promulgation of FWPCA regulations. This drop is considered to be principally driven by economics: a reaction to the sequence of economic calamities that have been visited upon the region since 1980, including the collapse of the oil market

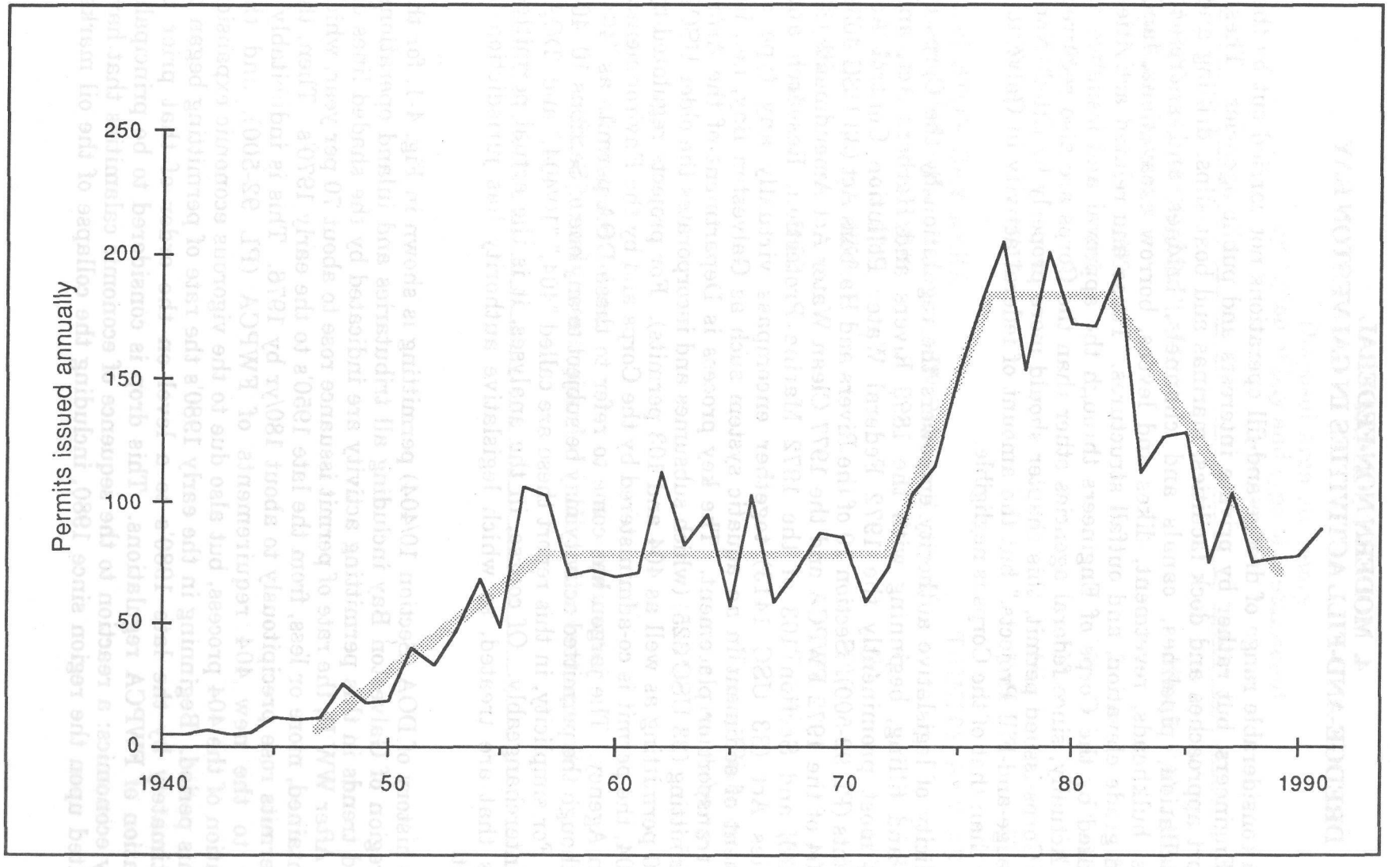


Fig. 4-1. Department of the Army (Section 10/404) permitting activity in Galveston Bay region, 1940-91

and its direct impact on offshore production, the southwest real-estate bust, and two nationwide recessions. There may also be some administrative contributions to this decline due to revisions in the 404 process, as noted later.

4.1. Compilation of DOA (404) permit data

With the evolution of law and regulation, summarized above, almost any physical modification to a watercourse or its adjacent wetlands now requires a Section 10/404 permit. Galveston District USCE has a considerable body of records documenting this permitting activity, in the form of microfiche copies of file records on 404 permits. While most of the information is from the past two decades, some information exists in the Corps files of earlier dredge-and-fill work, through Section 10 permitting. The permitting traffic is immense, as shown in Fig. 4-1, totalling 4,245 separate permits for 1940 through 1991, averaging about 100 per year since 1950.

This project reviewed and compiled the data and information holdings of the Corps files on Section 10/404 permits. This required working directly with the Galveston District files. Several federal agencies have digitized data bases of 404 permit information. These include the Galveston District itself, National Marine Fisheries Service of NOAA, and EPA. These agencies were contacted to determine if the information in the data bases would reduce the effort of file review of this project. Generally, the data bases suffered from two deficiencies, with respect to this project's objectives. First, they cover only recent activity (e.g., the past 3-10 years), having no records of the considerable activities over a longer period (Fig. 4-1). Second, the information was primarily administrative, e.g. dates of application receipt, permit review, addresses of applicant, etc. As will be seen below, the objectives of this project require quantitative specificity on location and dredge/fill works.

The chief sources of data were the permit application, including location maps and detailed drawings of the proposed activity, and the Statement of Findings, all of which were usually included in the permit file. Occasionally, environmental survey information was included (usually in recent permits, rarely in older permits). Even relatively minor activities, such as placement of pilings, require a permit, and even relatively modest proposals can entail many tens of pages in the file. A file comprising hundreds of pages is not unusual, and some permit applications total thousands of pages of information. In view of the large number of permits and the sheer bulk of the material supporting each permit, a two-pass approach to data compilation was employed. Pass One entailed a comprehensive inventory of all permits issued by the Corps for the Galveston Bay system, including date and number of permit, general location of the project (i.e., county and watercourse), and character of the work, according to one (or more) of the categories of Table 4-1. Pass Two comprised a quasi-statistical subsampling, focusing upon those permits for work within or immediately adjacent to Galveston Bay, including the lower reaches of tributaries flowing directly into Galveston Bay or a principal subsystem of the bay, and involving specifically

Table 4-1

Categories of project work for classification of Section 10/404 permits

Oil & gas development	Fill:	Revetment
Pipeline/cable	residential	Canal/channel
Dock/pier	industrial	Bulkhead
Boat slip, mooring basin	unspecified	Pilings
Marina	Dredging:	Levee
Boat ramp	new	Mitigation
Dike/groin/breakwater	maintenance	Temporary project
Borrow area		

Table 4-2

Detailed information on Section 10/404 permits compiled in Pass Two

DREDGE		FILL	
Volume (CY):			Volume (CY):
Area (Ac):		Area (Ac):	
Location:		Location:	
	Latitude		Latitude
	Longitude		Longitude
Material:	Sand & coarser	Material:	Sand & coarser
	Silt		Silt
	Mud/clay		Mud/clay
	Shell		Shell
	Unspecified		Unspecified
Disposal:	Upland	Sources of Material:	
	Open bay/open water		Dredged area
	confined		Upland
	unconfined		Sand bar
	Leveed		Other:
	Other:		Unspecified
	Unspecified		
Habitat Classification:		Habitat Classification:	
Habitat area loss		Habitat area loss	
gain		gain	

See Table 4-6

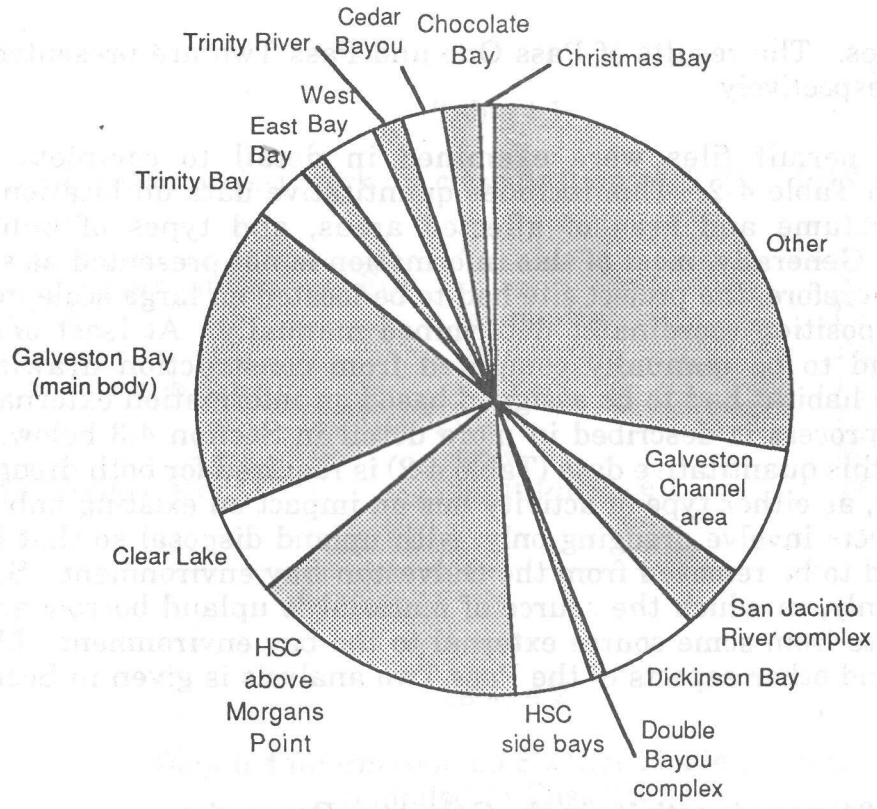
dredge or fill activities. The results of Pass One and Pass Two are presented in Section 4.2 and 4.3, respectively.

For Pass Two, the permit files were examined in detail to complete the information shown in Table 4-2. This includes quantitative data on location, as latitude/longitude, volume and area of affected areas, and types of habitat displaced or created. Generally, most of this information is not presented as such in the permit file. Therefore, the project site had to be located on large-scale maps of the area and the position coordinates determined manually. At least one of volume and area had to be manually computed from construction drawings, sometimes both. The habitat had to be assigned based on information external to the permit file: this process is described in more detail in Section 4.3 below. It should be noted that this quantitative data (Table 4-2) is required for both dredging and filling separately, as either type of activity has an impact on existing habitat. Of course, some projects involve dredging only, with upland disposal so that this material is considered to be removed from the Galveston Bay environment. Some projects involve fill only, in which the source of material is upland borrow areas or transport to the site from some source external to the bay environment. More information on this and other aspects of the Pass Two analysis is given in Section 4.3.

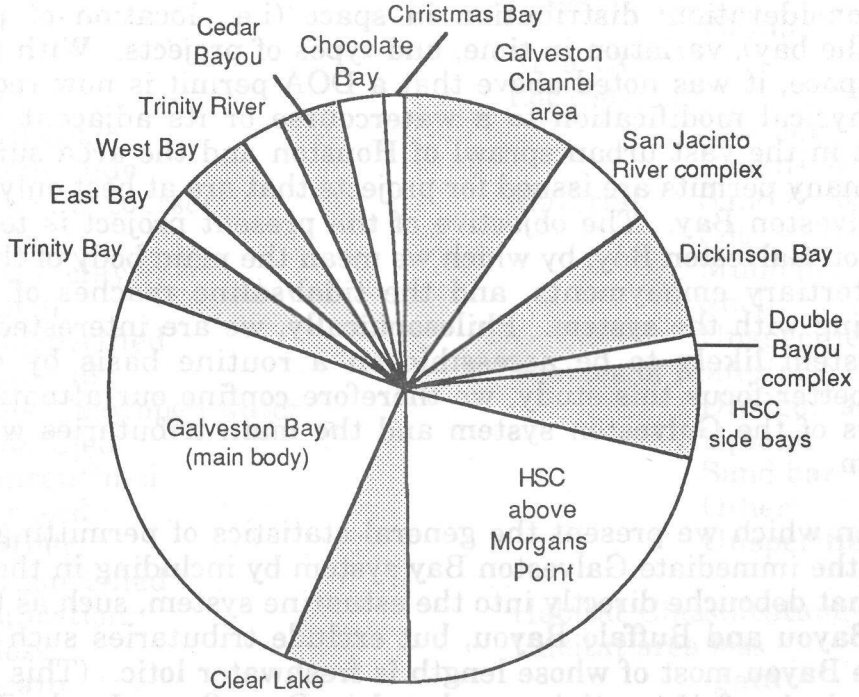
4.2 DOA (Section 10/404) permit activity in the Galveston Bay region

In characterizing 404 permitting in Galveston Bay, there are three dimensions necessary for consideration: distribution in space (i.e., location of permitted projects within the bay), variation in time, and types of projects. With respect to distribution in space, it was noted above that a DOA permit is now required for virtually any physical modification to a watercourse or its adjacent wetlands. This means that in the vast urban sprawl of Houston and the area surrounding Galveston Bay, many permits are issued for projects that are at best only remotely connected to Galveston Bay. The objective of the present project is to quantify impacts directly on Galveston Bay, by which we mean the main body of the bay, its secondary and tertiary embayments, and the tidal/saline reaches of principal streams conflowing with the system. Philosophically, we are interested in those areas of the system likely to be accessible on a routine basis by estuarine organisms. To better focus this study, we therefore confine our attention to the autonomous bays of the Galveston system and the main tributaries which flow directly into them.

In this section, in which we present the general statistics of permitting activity, we approximate the immediate Galveston Bay system by including in the analysis the tributaries that debouche directly into the estuarine system, such as Chocolate Bayou, Double Bayou and Buffalo Bayou, but exclude tributaries such as Brays Bayou and Vince Bayou most of whose length is freshwater lotic. (This exclusion is for overall analysis of 404 activity analyzed in Pass One. In the Pass Two analysis, where the project was positioned on a large-scale map, it was immediate whether the project site can be considered within the estuarine reach, and if not, the project was immediately excluded from further consideration.)



a. Galveston Bay region, including tributaries



b. Principal subregions of Galveston Bay

Figure 4-2. DOA (Section 10/404) permitting since 1940 by region

Table 4-3

Waterbody aggregation used in Figure 4-2 *et seq.*

Chocolate Bay:
- Chocolate Bay
- Chocolate Bayou

Christmas Bay:
- Bastrop Bay
- Christmas Bay
- Cold Pass
- Drum Bay

Cedar Bayou
- (Shorelines in Chambers & Harris Counties)

Trinity River & Anahuac Channel
- The Cutoff
- Channel to Liberty
- Cotton Lake
- Lost Lake
- Lost River
- Old (Trinity) River
- Trinity River main channel
- Cut Off bayou

Galveston Bay (main body)
- (Shorelines in Chambers, Harris & Galveston Counties)

Houston Ship Channel (Bayou reach)
- Barbour Cut Channel
- Main channel
- Channel behind Brady Island
- Buffalo Bayou
- Carpenters Bayou
- Carpenters Bayou Barge Canal

San Jacinto River complex
- Old River
- Old River Lake
- East Fork of San Jacinto River
- San Jacinto River

West Bay
- (Shorelines in Brazoria & Galveston Counties)

East Bay
- (Shorelines in Chambers & Galveston Counties

Clear Lake
- Clear Creek Channel
- Clear Lake (main body)
- Nassau Bay
- Seabrook Lagoon (Slough)
- Taylor Lake
- Clear Lake Shores Channel

Trinity Bay (main body)
- (Shorelines in Harris & Chambers Counties)

Double Bayou complex
- Double Bayou Channel
- East & West Forks

Dickinson Bay complex
- Dickinson Bay
- Dickinson Bayou
- Dickinson Bayou Channel
- Dollar Bay
- Moses Lake

Galveston Channel area
- Galv. Channel & Harbor
- Offatts Bayou
- Texas City Channel
- Tiki Island Channel

Houston Ship Channel side bays
- Tabbs Bay
- Black Duck Bay
- Burnett Bay
- Mitchell Bay
- San Jacinto Bay
- Scott Bay

Figure 4-2 shows the general distribution of 404 permits by watercourse. Panel (a) is the entire Galveston Bay region (corresponding to the data of Fig. 4-1), in which "Other" refers to nonconflowing tributaries. The lower panel excludes this category, better approximating the actual estuarine system of Galveston Bay. The waterbodies aggregated to make up each of these categories are listed in Table 4-3. As might be expected, 404 activity tracks closely intensity of development, the Houston Ship Channel (including side bays and the San Jacinto River) having the single highest density of permitting in the system. Moreover, the Houston Ship Channel, Galveston Channel (including Texas City Channel) and Clear Lake together account for about one-half of the permits issued for the entire system.

These watercourse categories are further aggregated to display variation of permitting intensity with time, as permits issued annually for the period 1940-91. This is plotted for the Houston Ship Channel region, the Trinity Bay region, and the West Bay region, broken down into their component watercourses, in Figs. 4-3 through 4-5, respectively. The remaining watercourses are lumped as the "main body" of Galveston Bay in Fig. 4-6, though this does not refer to as well-defined a geographical region as the preceding figures. Finally, each of these four "regions" are displayed in aggregate in Fig. 4-7.

Upon examination of these figures, one is immediately struck by the coherence of the time signal in the different subregions of the bay. The linear correlation array for the four "regions" of Fig. 4-7 is:

	Trinity	West Bay	Galveston Bay
Houston Ship Channel	0.60	0.81	0.64
Trinity Bay		0.61	0.65
West Bay			0.75

The high correlation among this data is exemplified by the scatterplots of Fig. 4-8. This correlation suggests that 404 activity in Galveston Bay is partially driven by a factor(s) that is uniformly exerted over the entire region. Economics would clearly be one such candidate factor. Others could include permit procedures, regional or nationwide policies, and staffing.

The distribution of Section 10/404 permits by category of project is shown in Fig. 4-9, for the 52-year period 1940-91. It must be re-emphasized that most projects issued a 404 permit comprise more than one type of activity. For example, a marina might require dredging of an approach channel, dredging of a basin, construction of a boat ramp, construction of piers and bulkheads, and perhaps filling. Although this would be one permit, it would be counted in each of these categories. Therefore, the categories of Fig. 4-9 are non-exclusive, and the sum of permits over all categories will exceed the total number of permits issued by a considerable margin.

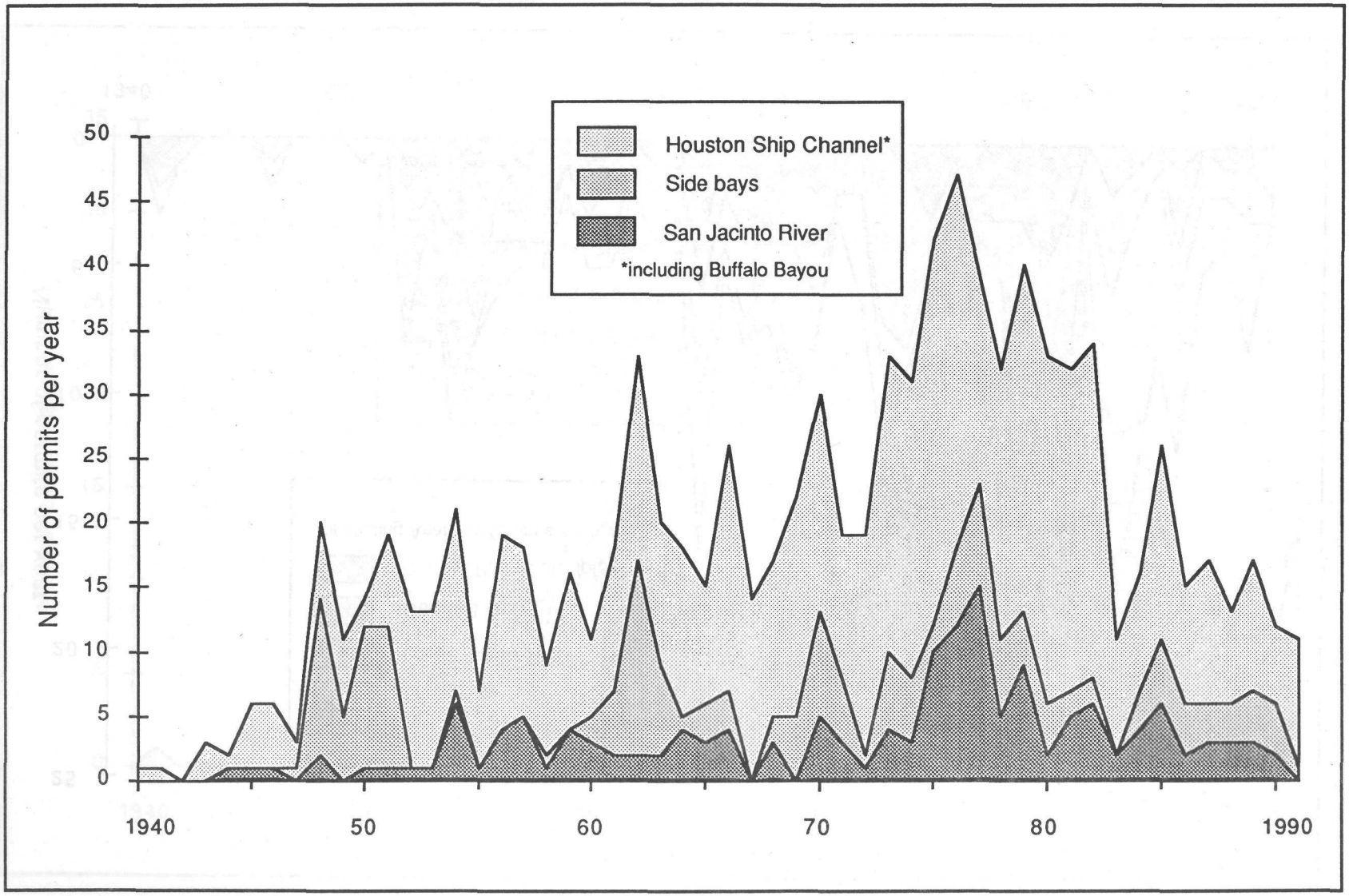


Figure 4-3. Annual DOA (Section 10/404) permits in Houston Ship Channel region, above Morgans Point

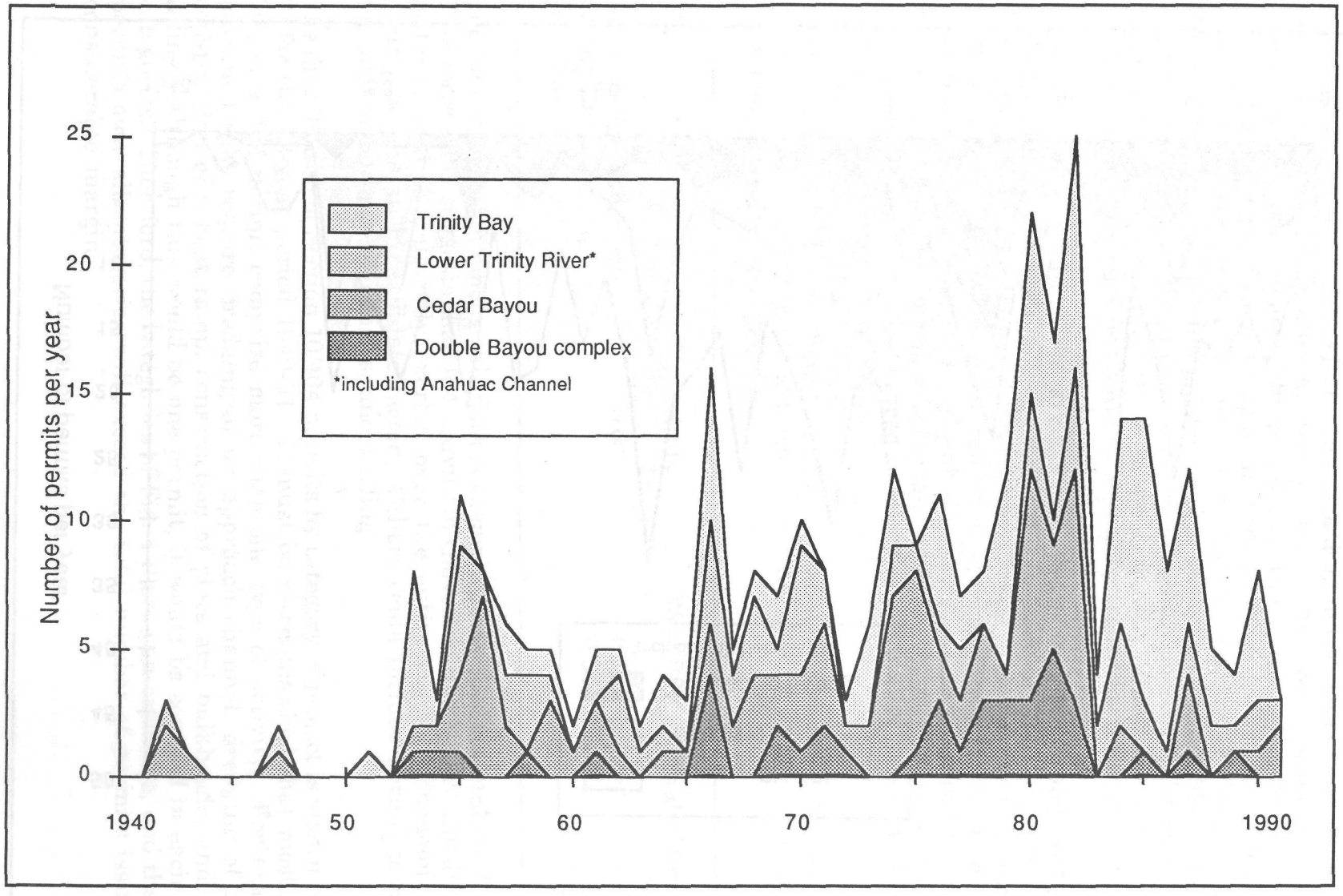


Figure 4-4. Annual Section 10/404 permits in Trinity Bay region

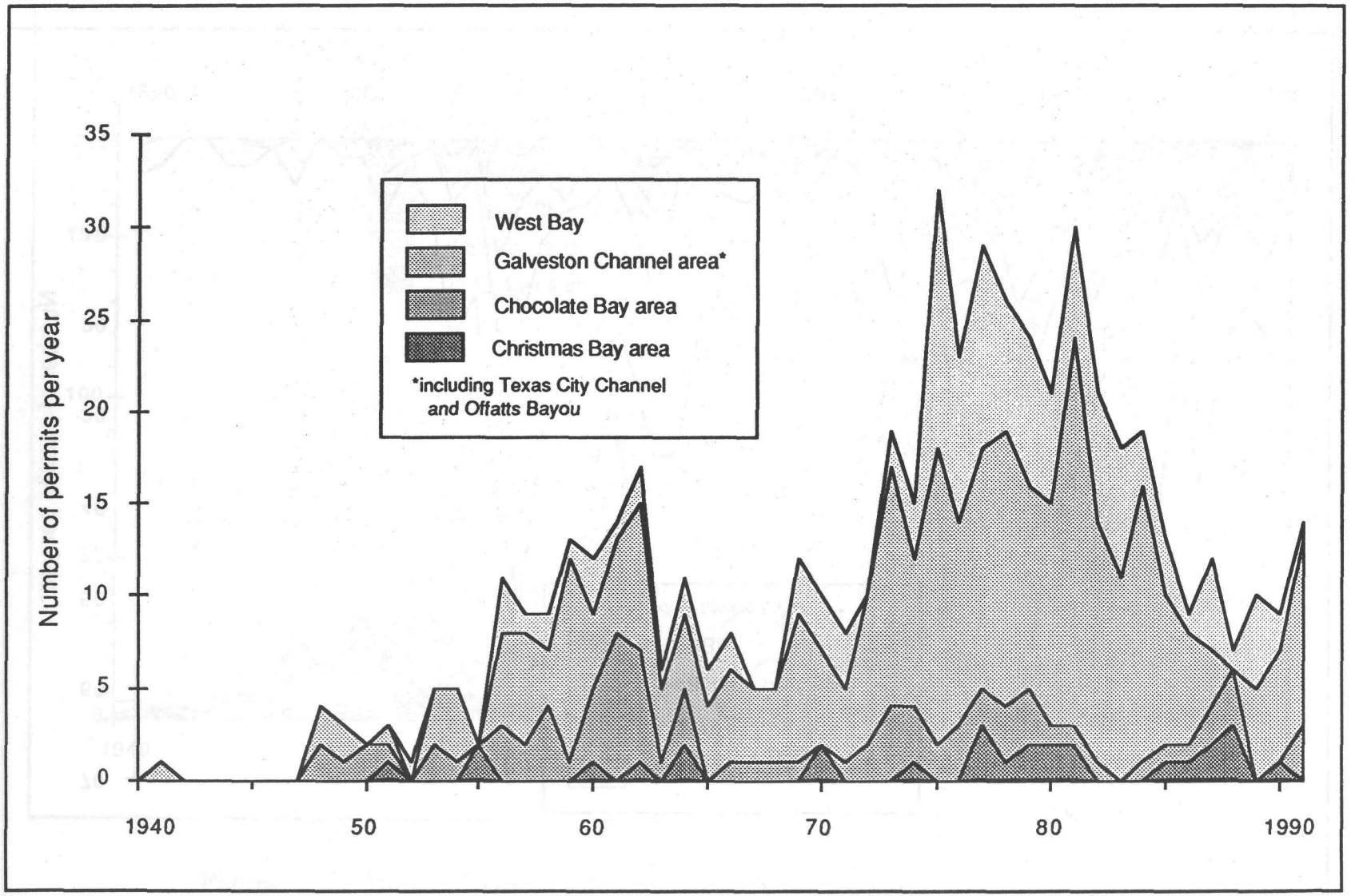


Figure 4-5. Annual Section 10/404 permits in West Bay region

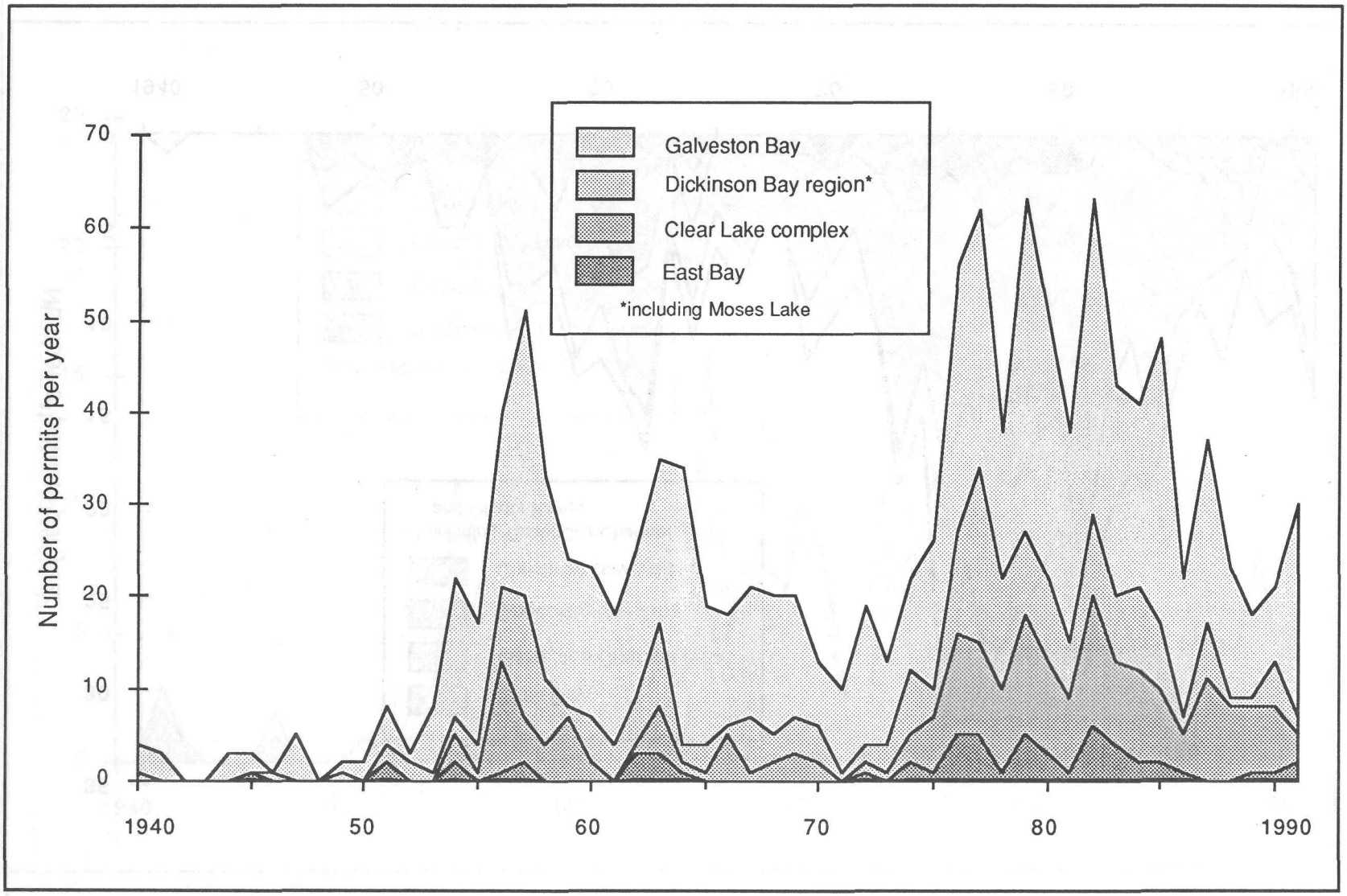


Figure 4-6. Annual Section 10/404 permits in main body of Galveston Bay (excluding West Bay and Trinity Bay)

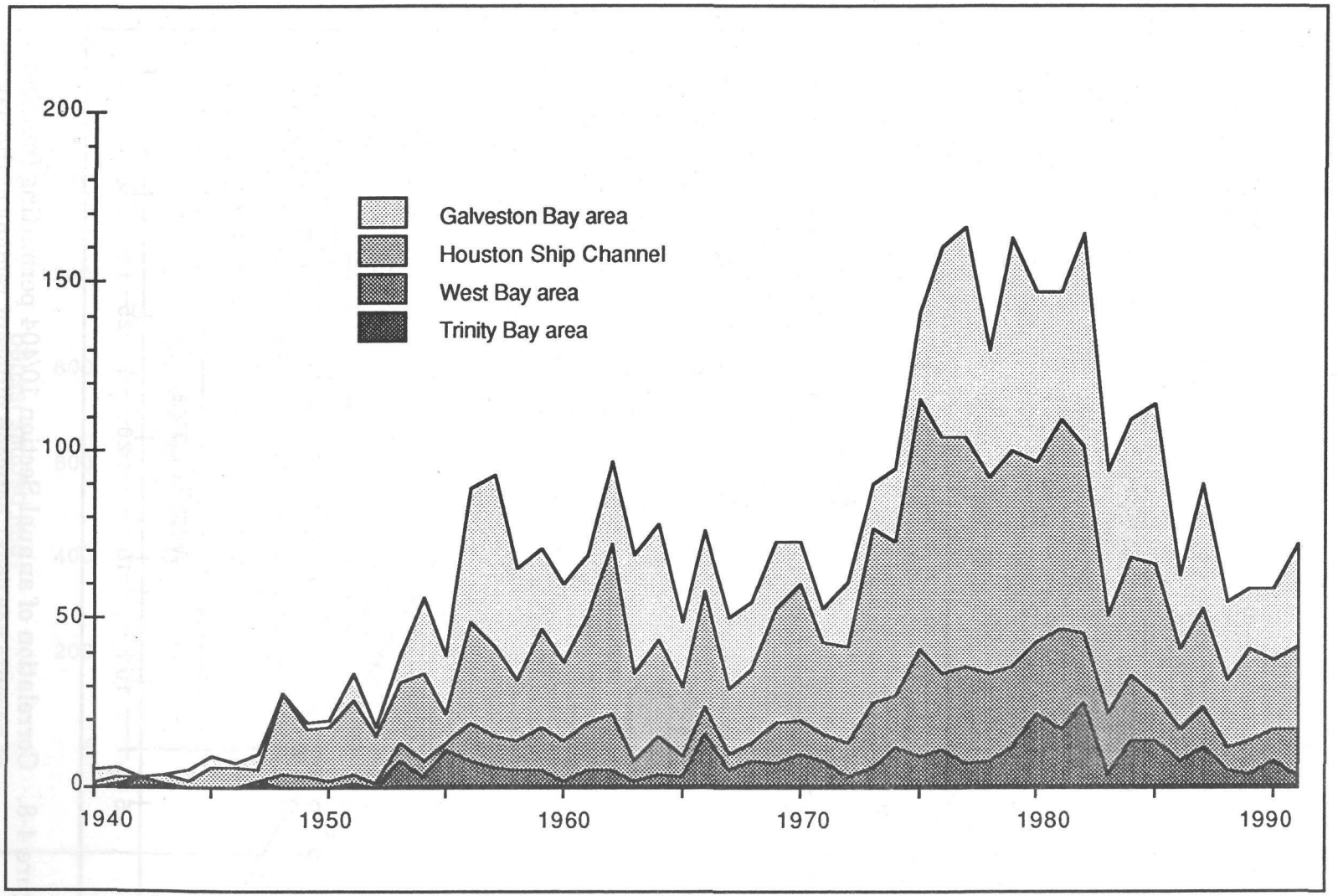


Figure 4-7. Annual Section 10/404 permits by major areas of Galveston Bay

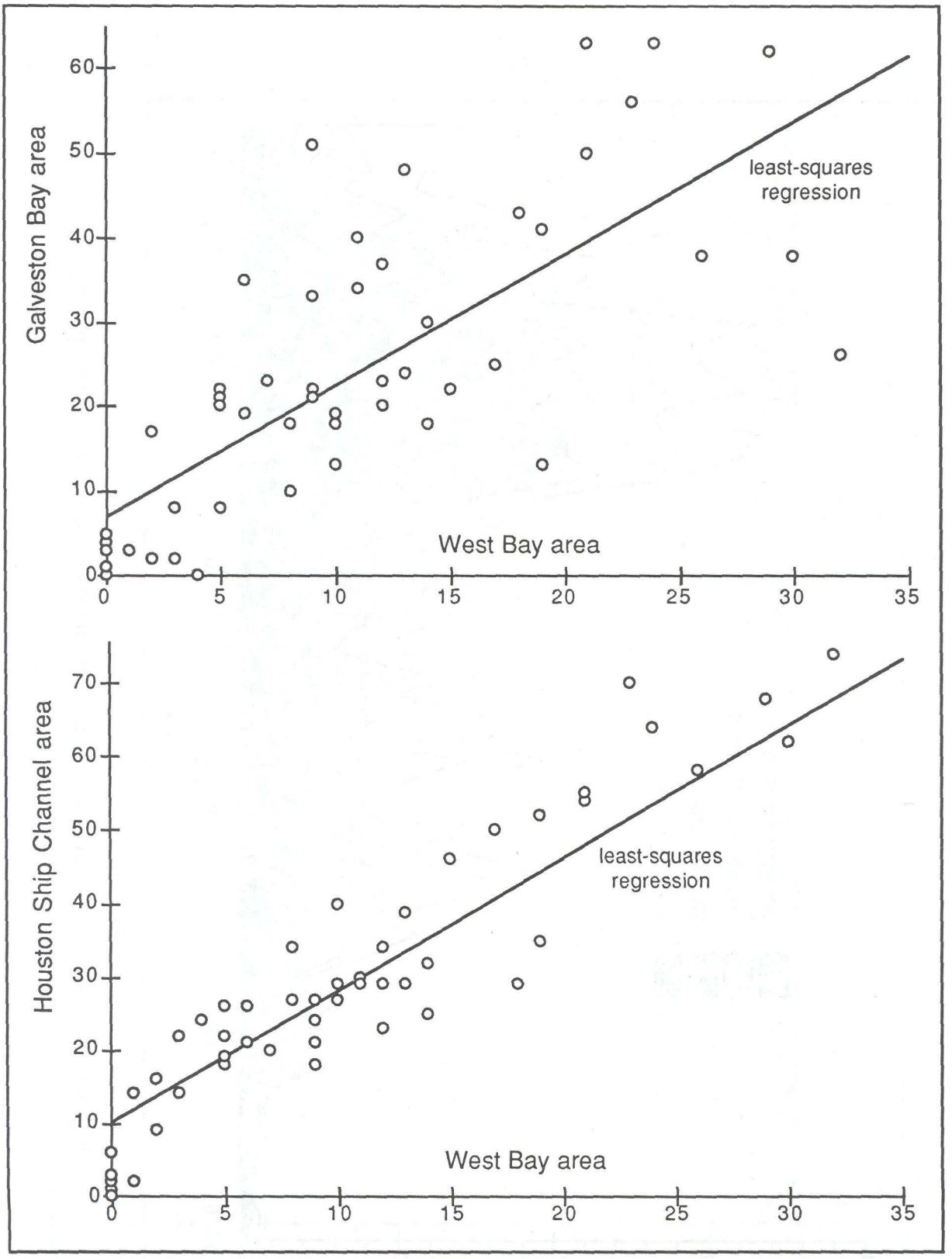


Figure 4-8. Correlation of annual Section 10/404 permitting (number of permits per year) between different regions of the bay

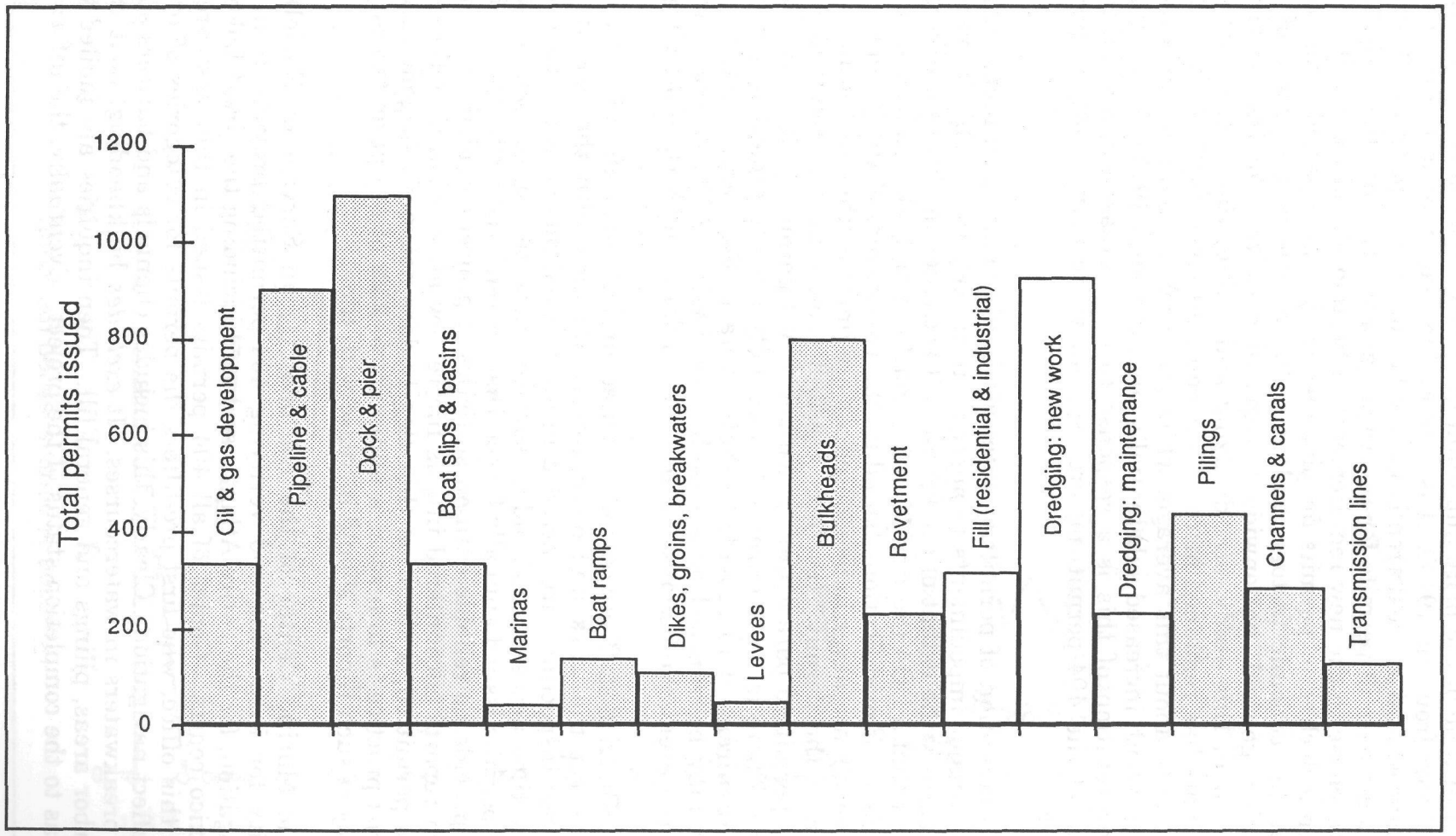


Figure 4-9. Section 10/404 permitting since 1940 by project type

The evolution in time of the more important of these categories is depicted in Fig. 4-10 *et seq*. Apart from the 1940's, it is remarkable that many of these categories of activity have shown no real trends in number of annual permits. There has been a slight increase in permits for revetment and levees since the early 1970's, perhaps in response to the new requirements of Section 404 of PL 92-500. There has also been a decline in permits for pipelines in the same period. Part of this could be due to economic factors, and part due to coverage of some of these activities under "general" nationwide or regional permits. For the activities of central concern in this study, *viz*. dredging and filling, the level of new-work dredging permits has remained more or less constant since 1950 at about 20 per year ranging 50% about this average, while the levels of maintenance dredging and filling have both increased substantially since the early 1970's, Fig. 4-10. The obvious interpretation of this is a response to the increased applicability and formalization of the 404-permitting process, but there may be other operative factors, as well.

While this examination of permitting intensity is illuminating in many respects, there are two major impediments to applying it directly to the objectives of this project, to quantify the extent of dredge-and-fill activities in Galveston Bay. The first is the fact that a DOA (Section 10/404) *permit* is simply that: a license to carry out certain physical modifications bound by the parameters of the permit. Many permitted projects are never implemented, or are implemented on a scale smaller than allowed in the permit. (In rarer cases, a project may be implemented in excess of the permitted parameters, or without a 404 permit at all, in violation of Federal law.) There is no requirement to actually put the project in place, and there is no requirement to provide "as-built" data to the Corps (though such a requirement may be imposed on a case-by-case basis). At best, then, the 404 permit files represent expressions of interest in undertaking certain activities.

Historically, District staff occasionally visited project sites after issuance of a permit to inspect the work and determine compliance with the permit. The results of these inspections are included in an internal memo in the permit file. However, the time necessary to conduct such an inspection in comparison to the hundreds of permits issued annually by the District rendered such reports of such rarity as to provide no reliable data on statistics of project completions. (In fact, the few such reports encountered in this file review all verified that the project was built as permitted, a situation that clearly does not apply in general.) The present Corps practice is to inspect a minimum of 25% of the permits issued, so the frequency of such reports should increase with time.

The Atlantic Marine Center of the National Ocean Service in Norfolk has responsibility for inspecting and verifying 404-permitted projects that could impact navigation, for the entire Atlantic seaboard including the Great Lakes and Gulf of Mexico coasts. Copies of all 404 permits issued in this vast area are provided to this office, who first pre-filters the permits for categories of projects that could affect navigation. Clearly, this includes channels and barriers such as levees and breakwaters in watercourses. It *excludes* bulkheading, boat ramps, piers in harbor areas, pilings and general fill. Then inquiries are mailed to the permittees as to the completion status of the project. Eventually, the information

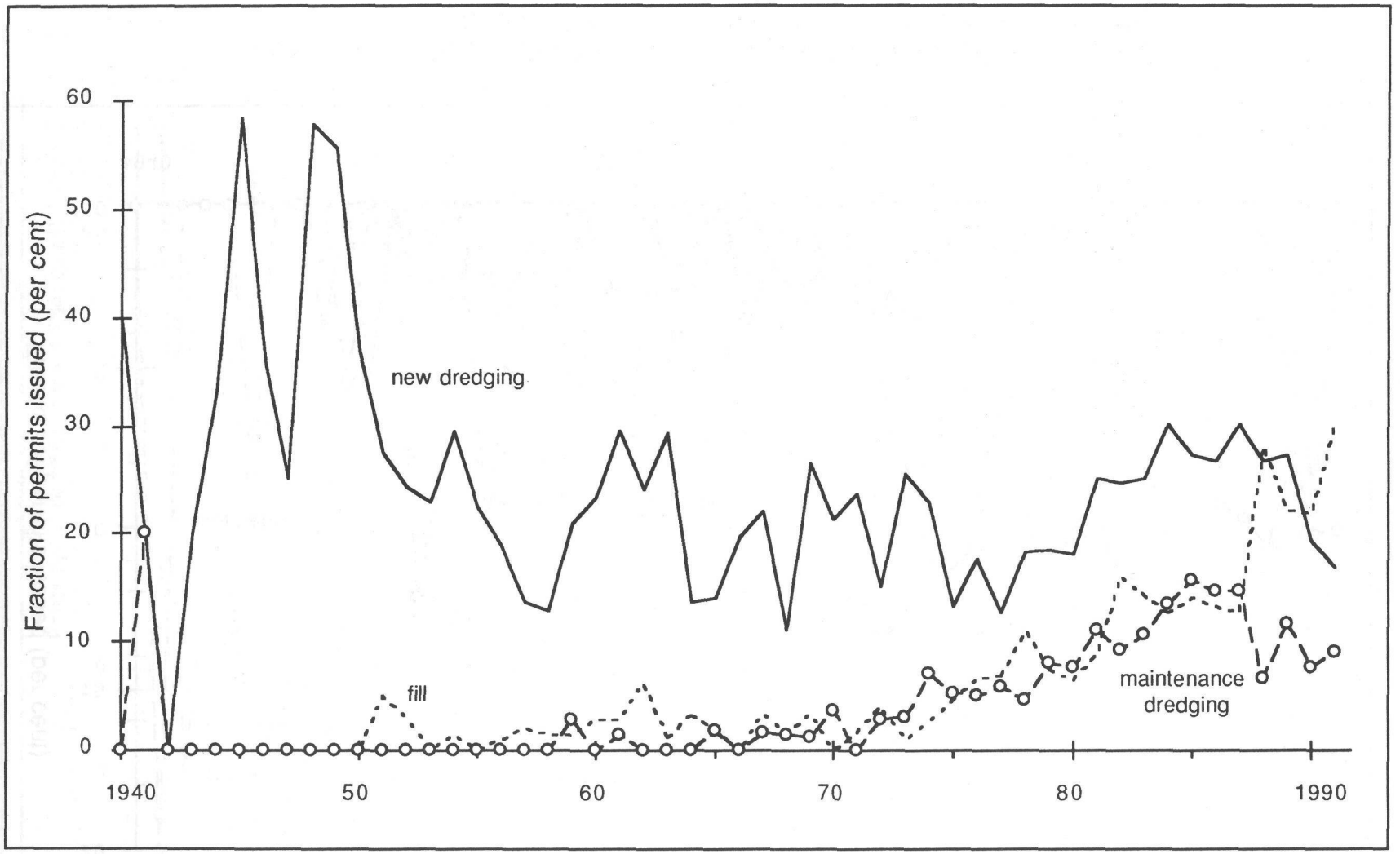


Figure 4-10. Proportion of Section 10/404 permits for dredging and filling, since 1940

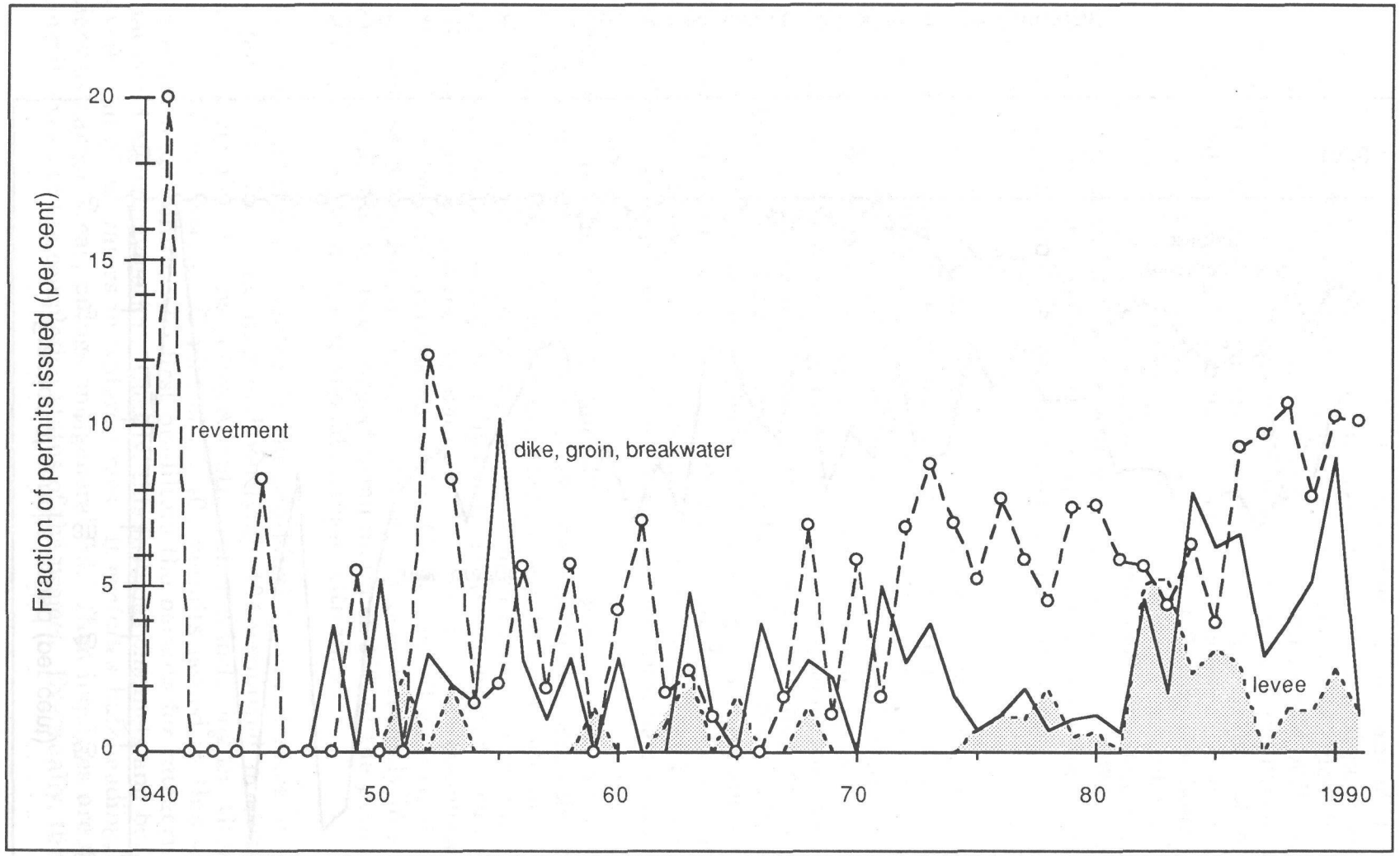


Figure 4-11. Proportion of Section 10/404 permits for shoreline revetment, dikes and other internal flow barriers, and levees, since 1940

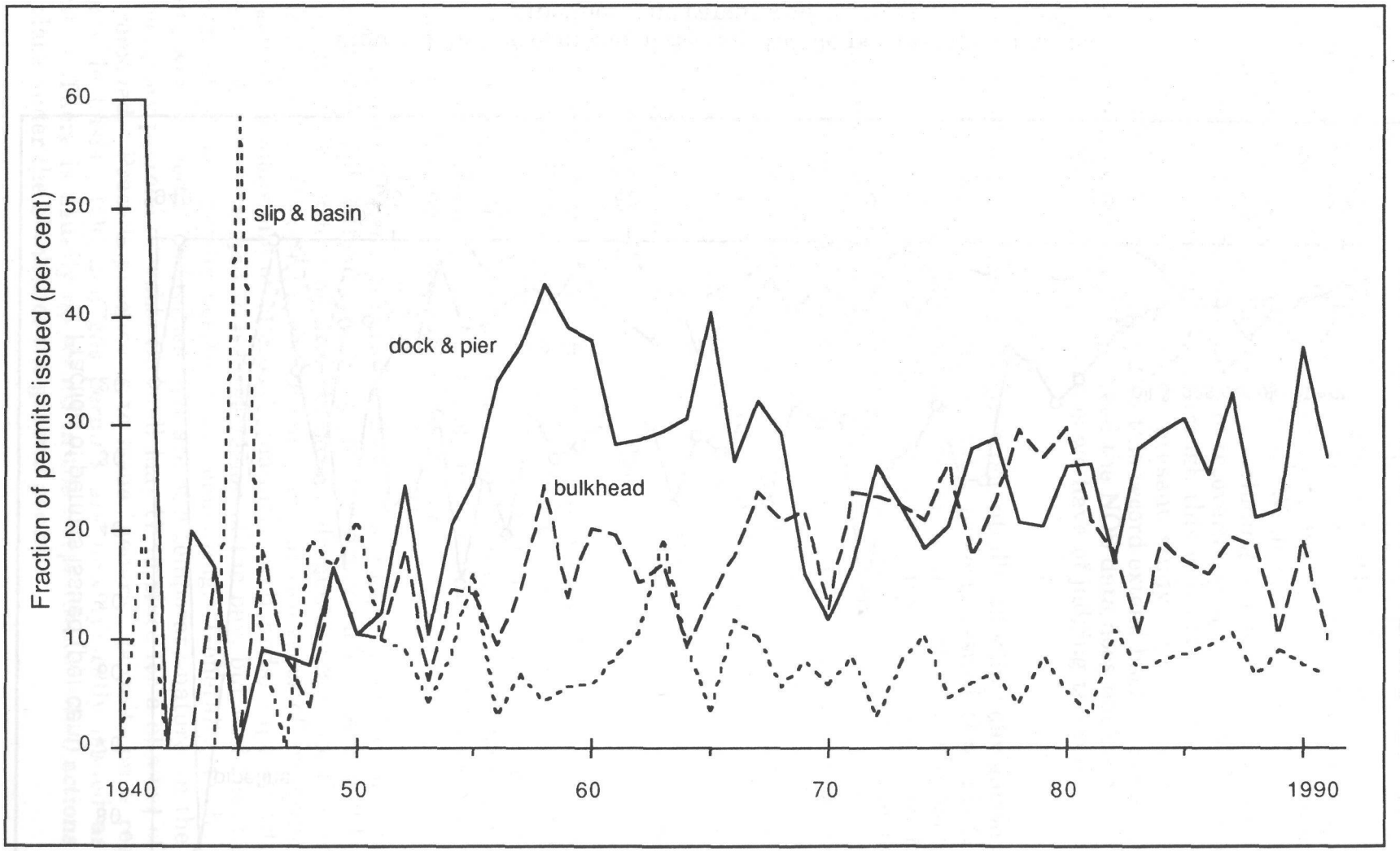


Figure 4-12. Proportion of Section 10/404 permits for boat slips and basins, docks and piers, and bulkheads, since 1940

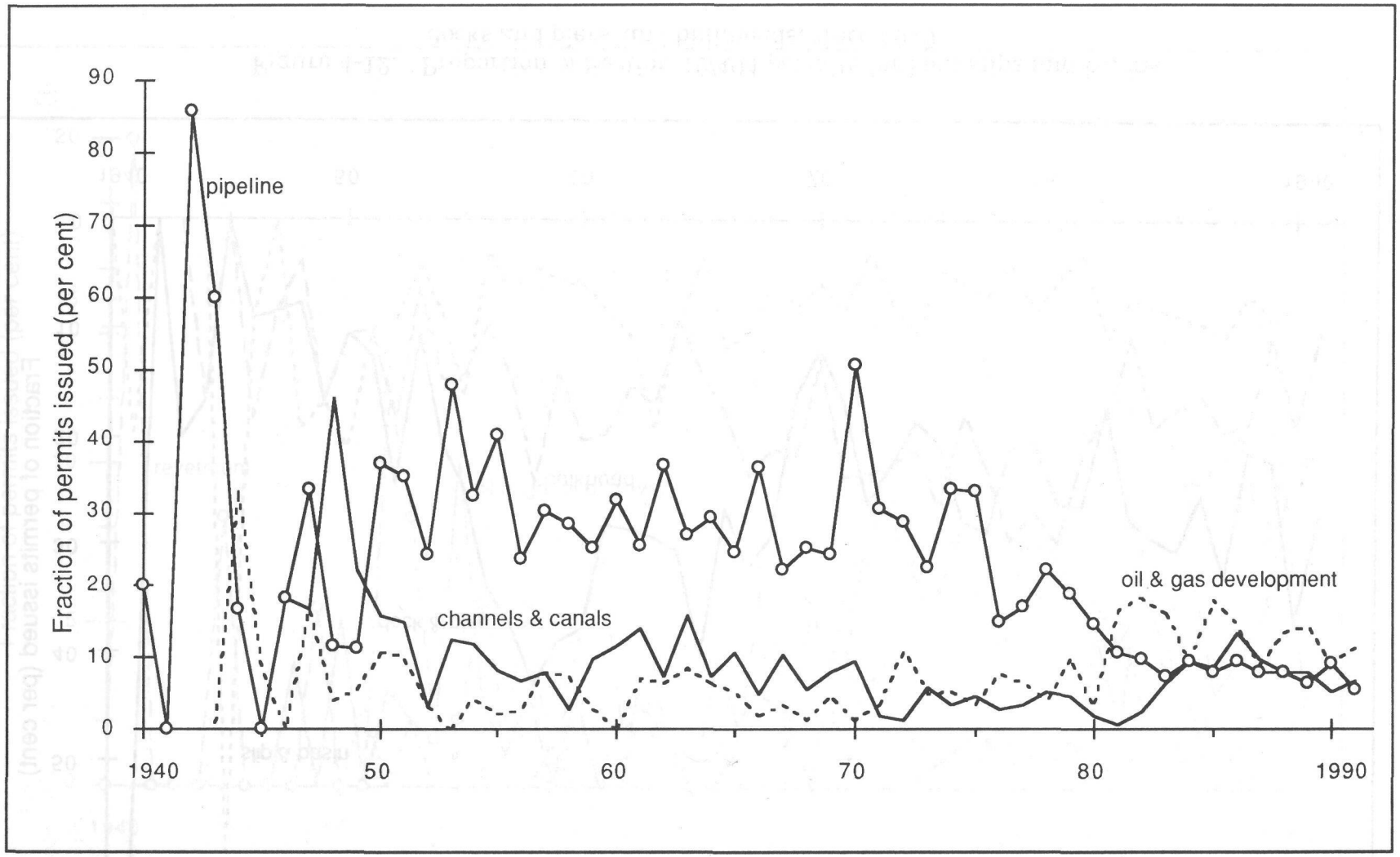


Figure 4-13. Proportion of Section 10/404 permits for oil & gas, pipelines, and canals and channels, since 1940

on completed projects is forwarded to NOS offices in Rockville for incorporation into *Notices to Mariners* and NOS navigation charts. Informal records are kept on the statistics of responses and project completions within the Atlantic seaboard zone (Table 4-4), provided to this project by R. Blevins (NOS, pers. comm., 1992), and summarized in Table 4-4 and Fig. 4-14. While at one point in this process, the information is aggregated by bay system, including Galveston Bay, it is not filed or retained this way. So, the only means of recovering completion data from the NOS records would be to physically sort through this information in Rockville, a task clearly beyond the resources of the present study. (Note the thousands of responses on file, Table 4-4.) Nor does this record extend back as far as the period of analysis for the present study; indeed the NOS data does not even antedate PL 92-500. It is, however, the best means we have of judging the completion of 404 permits.

Clearly, the nationwide trend in projects potentially affecting navigation does not appear to follow the same trends as total projects issued through Galveston District (Fig. 4-1). The hypothesis that this permitting activity is ultimately driven by economics may account for this, due to the differences between the Texas regional economics and the nation prior to 1985. However, there are other potential corrupting factors, not the least of which is that the NOS monitoring procedures are very informal and subject to change according to the personnel assigned to the task. Probably, the only conclusion of any consequence that can be drawn from this data is that the rate of completion of 404-permitted projects is low, on the order of 30%, if one assumes the same relative frequency of completions in the permittees not responding to the NOS inquiry, if one assumes the same relative frequency for the project categories not investigated, and if one assumes the same relative frequency for the Galveston area as exhibited on the entire Atlantic seaboard.

The second impediment to the use of historical 404 permit records in this study is that the specific data on 404-permitted projects is generally non-quantitative. There is no standard, straightforward tabulation of project location, or volumes and areas of regions affected by dredging and filling. Some permits are confused as to planned activities, have incomplete or inaccurate drawings, or have appended multiple modifications and extensions.

Some are blanket or general permits, that allow a type of activity of certain scale (or dimensions) but without specifics as to how many such projects will be built or in what timeframe. Older oil and gas permits frequently fall into the category of "blanket" permit, providing specification of one or two types of exploratory wells, with generic dimensions of approach channels, well pads, superstructure, etc., which will be implemented in a large region of the bay, but without specifics on numbers of wells, specific positions or scheduling. Generally, such "blanket" permits were issued for activities that are of a temporary nature: in the example of exploratory petroleum wells, the well may be in place for a number of months, then removed. Present practice is to issue "general" permits on a regional or nationwide basis. (Oil and gas permits are now typically issued as general permits.) There is usually no record in the Corps files of what actions actually take place under the blanket or the general permit.

Table 4-4

NOS DATA ON 404-PERMIT COMPLETIONS
R. Blevins (NOS., pers. comm., 1992)

*year**	*inquiries*	*responses*	*completed projects*
1973	2121	1449	506
1974	2684	1906	561
1975	2083	2014	875
1976	3290	2366	910
1976-77	3314	2196	1236
1978	2290	1487	940
1979	1905	1275	323
1980	1326	981	56
1981	1000	757	101
1982	766	648	376
1983		data incomplete	
1984		ditto	
1985		ditto	
1986		ditto	
1987		ditto	
1988		ditto	
1989	3100	1643	859
1990	4222	2371	965
1991	3112	1990	798

* 1973-81 are for the U.S. fiscal year October-September
1982-91 are calendar years

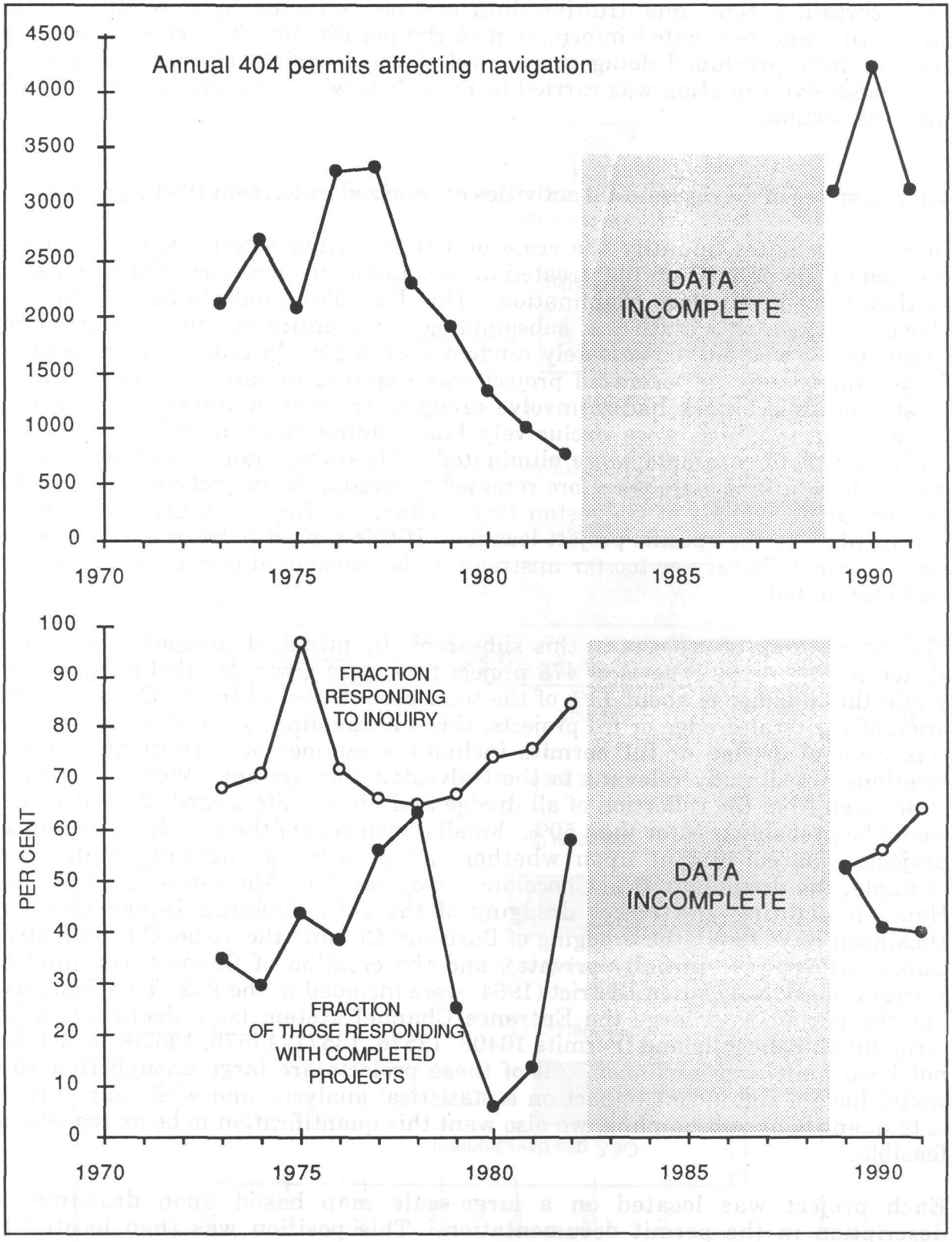


Figure 4-14. NOS data on Atlantic seaboard 404-permit completions, see Table 4-4

To a certain extent, quantitative data can be extracted by a reading of the application and associated information in the permit file. The sheer number of such permits precluded doing this for all of the District holdings, but a fairly comprehensive sampling was carried in Pass Two, whose results are described in the next section.

4.3 Estimates of dredge-and-fill activities authorized by Section 10/404 permits

In order to better quantify the scale of 404-permitted activities, a substantial fraction of the permits on file, treated in the statistical summary of the preceding section, were given close examination. This Pass-Two analysis (see Section 4.1 above) represented a statistical subsampling of the entire permit holdings at the Corps, but it was not a completely random subsample. In order to be considered for detailed study, a permitted project was required to satisfy several criteria. First, the project work had to involve dredging (new or maintenance) or filling. Thus, projects which were exclusively bulkheading (without fill) or dock/pier construction, for example, were eliminated. (However, many bulkhead projects involve backfill and were therefore retained.) Second, the project had to lie within the estuarine regions of Galveston Bay. Thus, the first item examined in the permit file was the specific project location. If this proved to be in the freshwater reach of the tributary or too far upstream to be considered estuarine, the project was eliminated.

The distribution of projects in this subsample by principal categories of work is shown in Fig. 4-15. A total of 478 project files were given detailed examination. While this number is about 11% of the total permits issued in the Galveston Bay area, of the total dredge or fill projects, this subsampling is about 35%. Further, this total of dredge or fill permits includes a number of permits that are in locations not directly relevant to the Galveston Bay system. Were these to be eliminated from the collection of all dredge-and-fill permits award, the subsample would be probably greater than 50%. Finally, inclusion of the very large permitted projects was contingent upon whether the project was actually built. For example, the dredging of the Chocolate Bayou canal by Monsanto (1960-61), the Houston Lighting and Power dredging of the P.H. Robinson Intake Canal in Dickinson Bay (1963), the dredging of Barbours Cut and the Texas City Industrial Canal (which were initially private), and the creation of Bayport Terminal by Harris County Navigation District (1964) were included in the Pass-Two data base, but the permit to enlarge the Entrance Channel system for a deepwater O&G terminal on Pelican Island (Permits 10400, 13576, 13577, 13578, 13579)--which has not been built--was excluded. All of these projects are large enough that they would have a significant impact on a statistical analysis, and while our purpose is to quantify by subsampling, we also want this quantification to be as realistic as feasible.

Each project was located on a large-scale map based upon drawings or description in the permit documentation. This position was then located by latitude and longitude coordinates. In a few instances, the project was sufficiently large, or the dredging and disposal areas were so different, that the

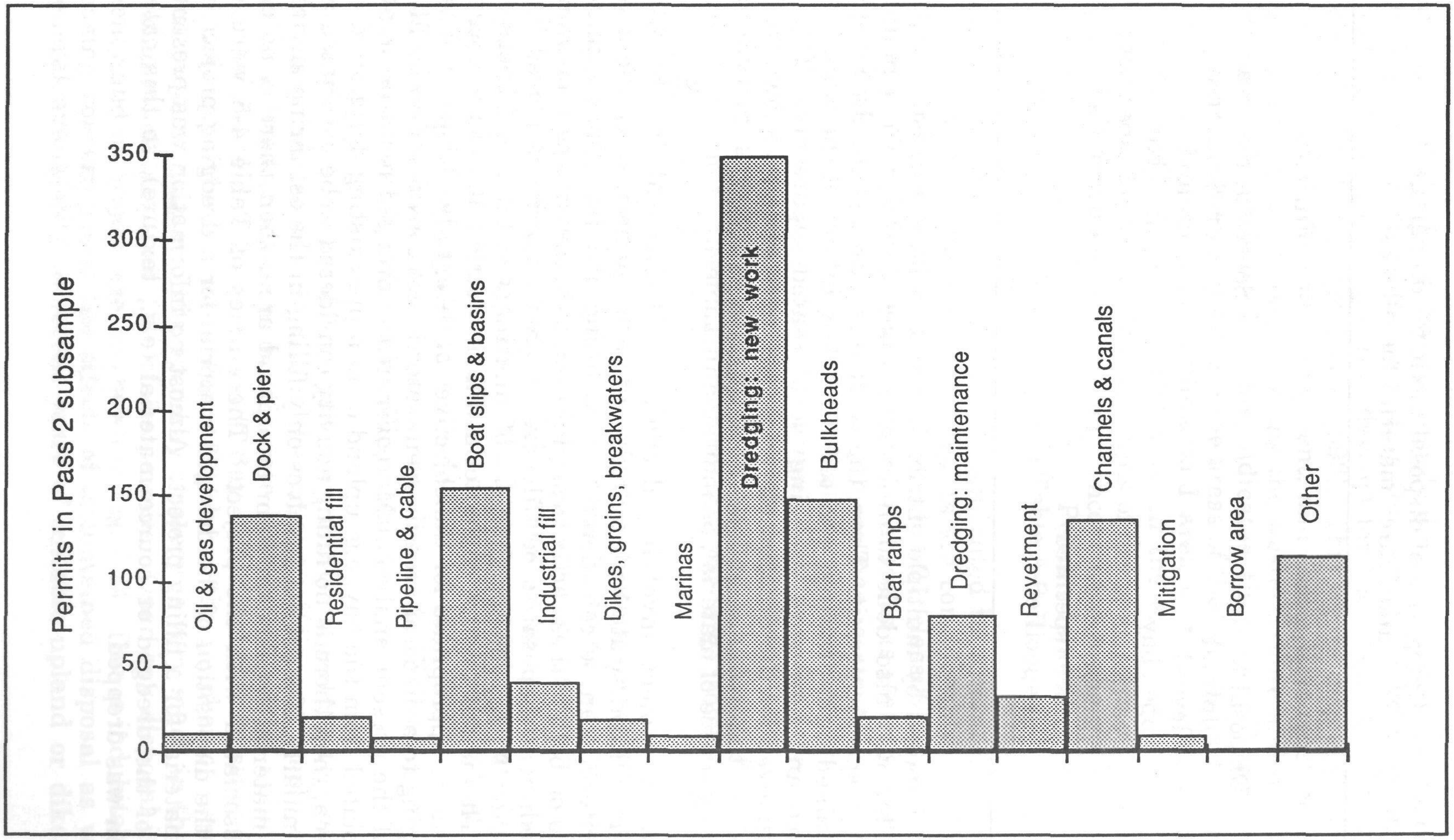


Figure 4-15. Subsample permits by project type

Table 4-5

Categories of disposal tactic for dredging and source material for filling

Dredging	*Filling*
Disposal tactic:	Source of material:
upland	dredged area
leveed	upland
open bay	sand bar
confined	other (specified)
unconfined	unspecified
other (specified)	
unspecified	

project was handled by multiple entries in the data base, corresponding to each activity. This was also done to differentiate new dredging from maintenance dredging for a specific permit. Then, the volume and area of the dredging activity were determined from drawings and technical descriptions of the work. For this, maintenance and new-work dredging were treated separately. The type of disposal employed for the dredged material was categorized as shown in Table 4-5. Similarly, the volume and area of any fill work was determined and categorized by source of material, as indicated in Table 4-5.

In general, a project involving dredging and disposal in the estuarine environment will constitute both a dredge and a fill project, since the disposal of dredged material can be considered to be a filling activity. Such a project will require data on both of these activities. However, to better sharpen the analysis we consider sediment disposal to be "fill" only if that material is placed in a well-defined region with some mechanism of limiting the further dispersal of the material. This is not the use of the term "fill" in Section 404 of the Clean Water Act, but is more appropriate for the objectives of this study. Disposal of sediment by discharging to a disposal area in open water is not considered to be fill for the purposes of the present analysis. Moreover, if the dredged material is placed in an area isolated from the bay, e.g. upland or in a pre-existing designated confined disposal area, then there is no filling activity considered to be associated with the project. Similarly, if a project involves only filling in the estuarine environment, e.g. using material trucked in from an upland area, then there is no dredging activity associated with the project. The entries of Table 4-5 were used to document the disposition of the dredged material for a dredging project, and the source of material for a filling project. Almost no information was present on the character of the dredged or source material (e.g., texture), so this category of information was dropped.

The distribution of the Pass Two subsample data set within the Galveston Bay system is displayed in Fig. 4-16, by sorting the projects by latitude/longitude into the GBNEP hydrographic segments, devised for the Water Quality Status and Trends project (Ward and Armstrong, 1992). This figure displays the number of permits within each hydrographic segment, and shows that most permits are in the western segment of the bay, i.e. along the western shore and in West Bay, or in the Houston Ship Channel. This indicates that the subsample is a fair geographical sampling since these are the areas of the bay under the most intense development. The cumulative volume and area of the dredging projects are shown respectively in Figs. 4-17 and 4-18, in the same format. All told, the projects analyzed total 64.2 x 10^6 cubic yards of dredging from a total area of 2980 acres. Both volume and area are strongly concentrated in the upper Houston Ship Channel and the vicinity of Galveston and Pelican Island. Specific data on a segment-by-segment basis are presented in Table A-7 *et seq.* of the Appendix.

The total dredge volumes and areas are dominated by a minority of very large projects, while most of the permitted projects are considerably smaller. This is demonstrated by the data of Figs. 4-19 through 4-21, classifying the projects into size categories. Note should be made that the abscissa is plotted logarithmically, so the bell-shape in fact indicates that project size is strongly skewed toward smaller projects. For dredged volume, half of the projects are less than 30,000 cu yds which is only the lower 1% of the range. Similarly, for dredged area, about half of the projects are less than 1 acre, which is the lower 0.3% of the range. As defined here, relatively few 404 projects involve fill, about 6% of the data. Moreover, these tend to be small in area without the large isolated projects typical of the dredging projects, Fig. 4-21.

An inspection of the time history of dredging project scale, as measured by the area dredged, Fig. 4-22, discloses no discernible trend, except perhaps that arising from the increase in number of permits over the 1940-80 period, and the increased dispersion of size. More detailed statistics on trends, as measured by linear regressions in time for each of the hydrographic segments (where there are sufficient data for such an analysis), are given in Table A-7 *et seq.* of the Appendix. There does appear to be a decline in both frequency and size of permitted projects involving channels, as shown in Fig. 4-22, in which the channel projects are differentiated by filled squares.

While the scale of a dredge-fill project is certainly important to evaluating its potential impact on the bay, so also is the strategy of disposal employed. By far, the dominant disposal strategy in this data base is the use of upland disposal areas, i.e. areas isolated from Galveston Bay. This includes existing designated, confined dredged disposal sites. Fig. 4-23 shows the number of permits using various disposal strategies. The open-bay strategy is very much in the minority, representing much less than 10% of the permits. Open-bay disposal is declining in frequency and by project size, as shown in Fig. 4-24. This is indubitably a result of increasing concern about the effects of uncontained disposal as well as the more general availability in recent years of suitable upland or diked disposal areas.

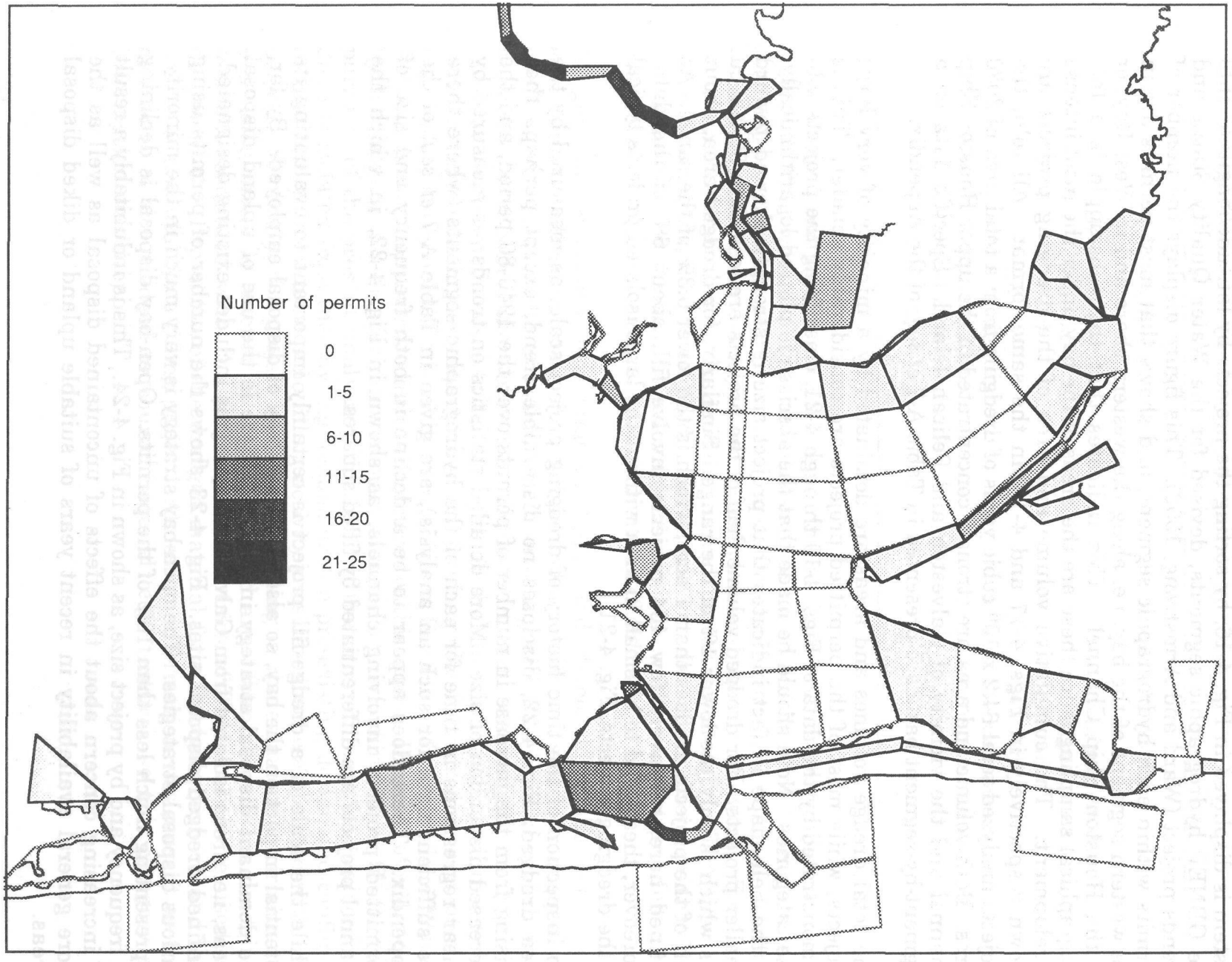


Figure 4-16. Permitting intensity distributed by GBNEP hydrographic segment

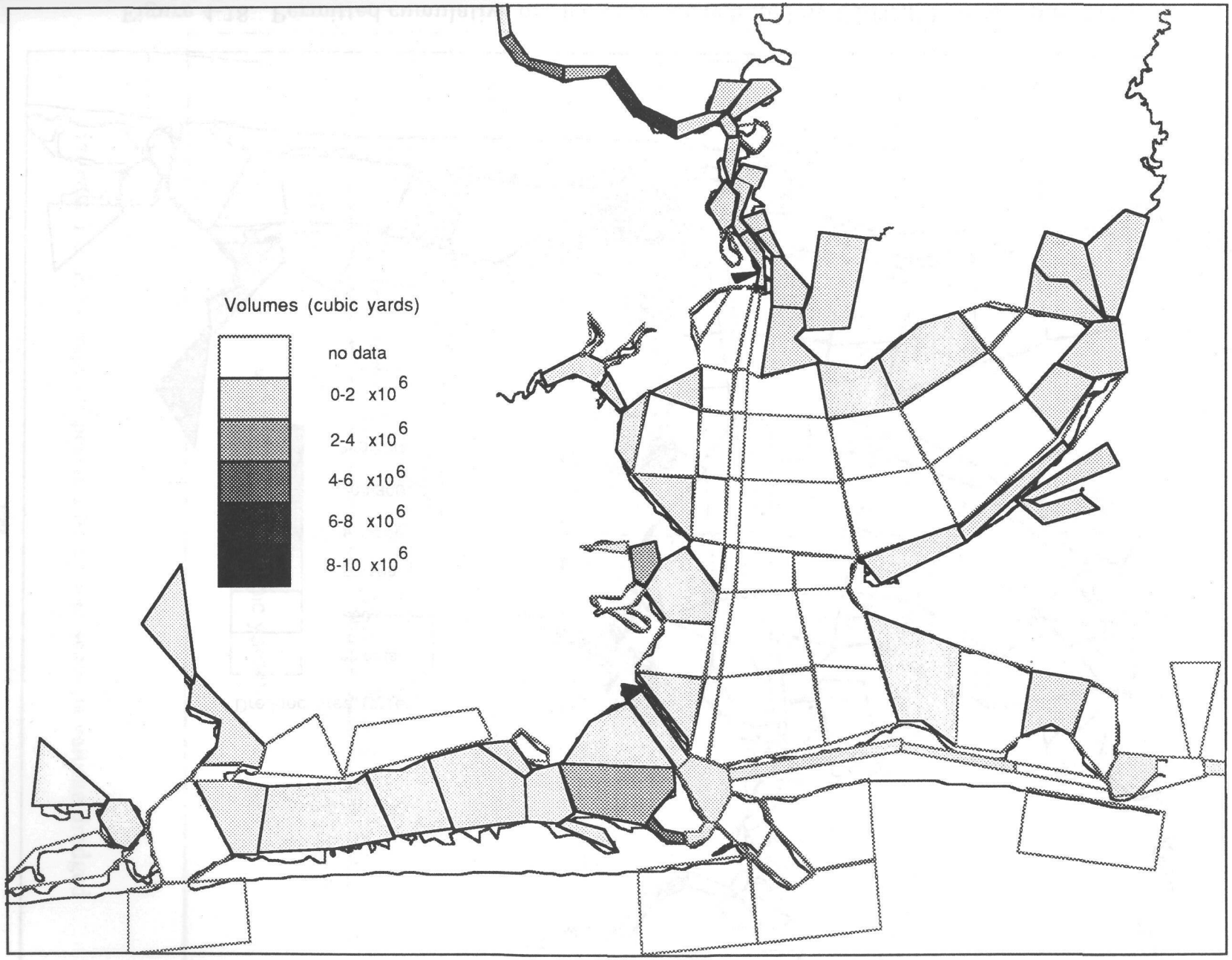


Figure 4-17. Cumulative 404-permitted dredged volumes distributed by GBNEP hydrographic segment

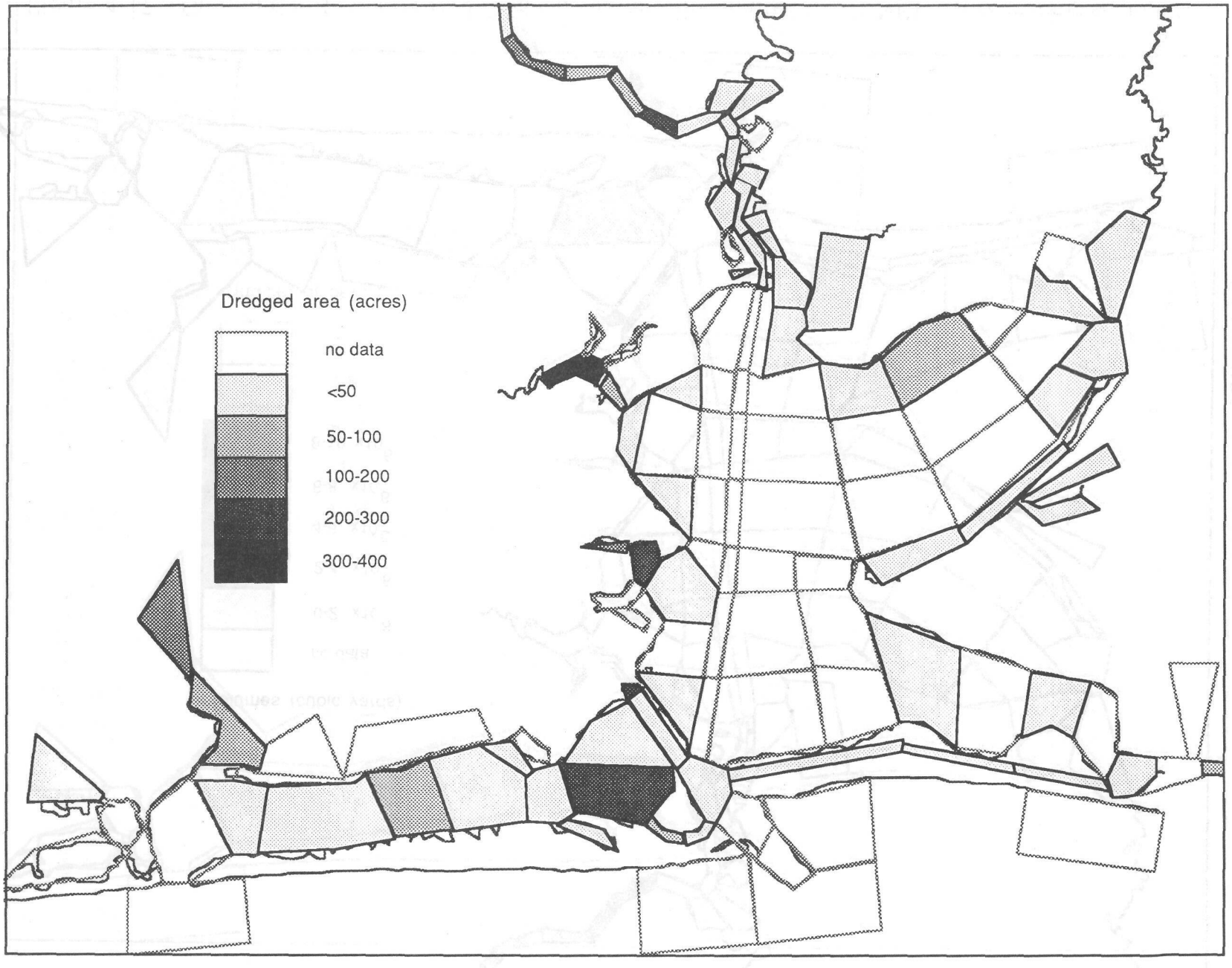


Figure 4-18. Permitted cumulative dredged area distributed by GBNEP hydrographic area

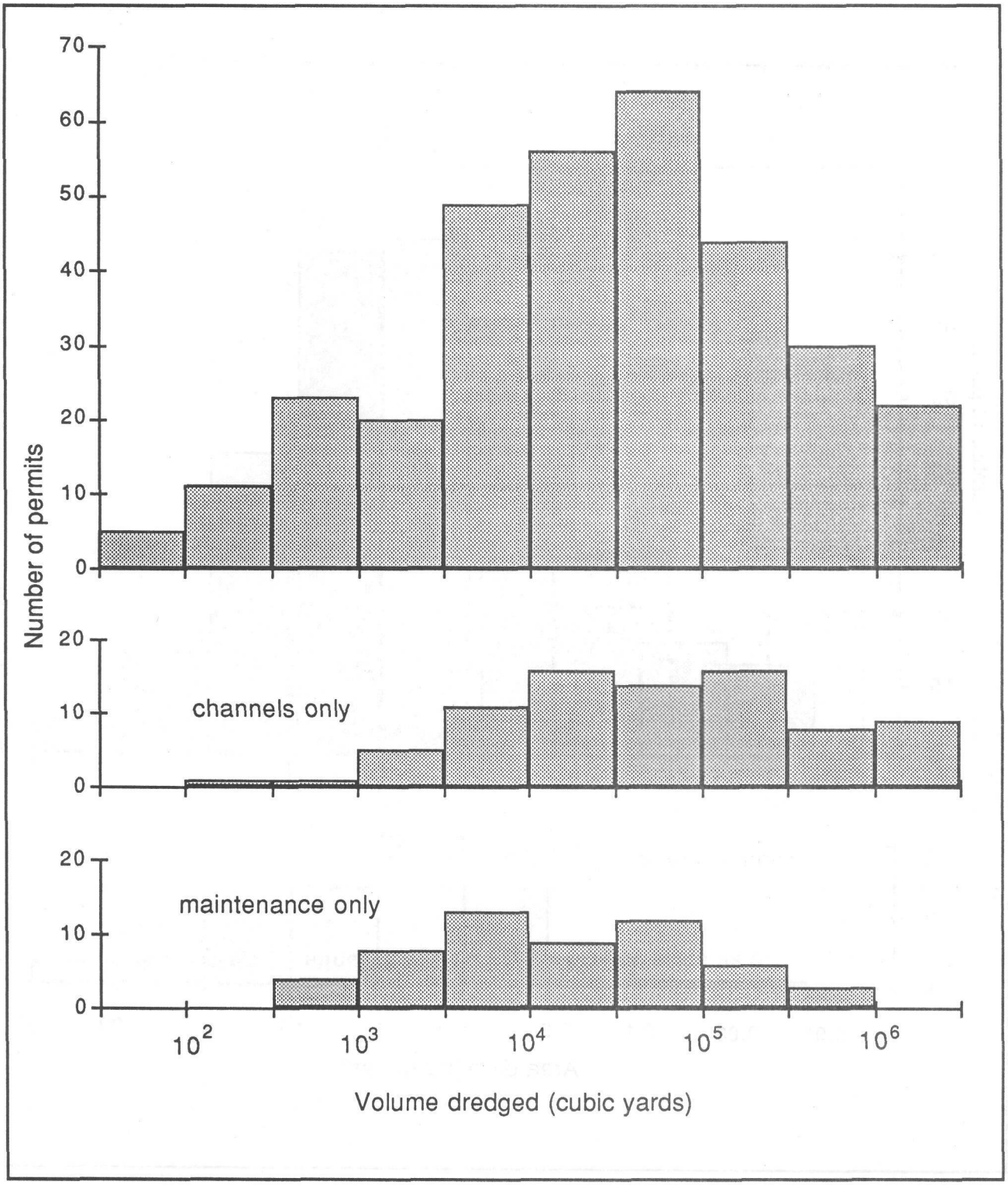


Figure 4-19. Frequency of permits by project scale as volume dredged

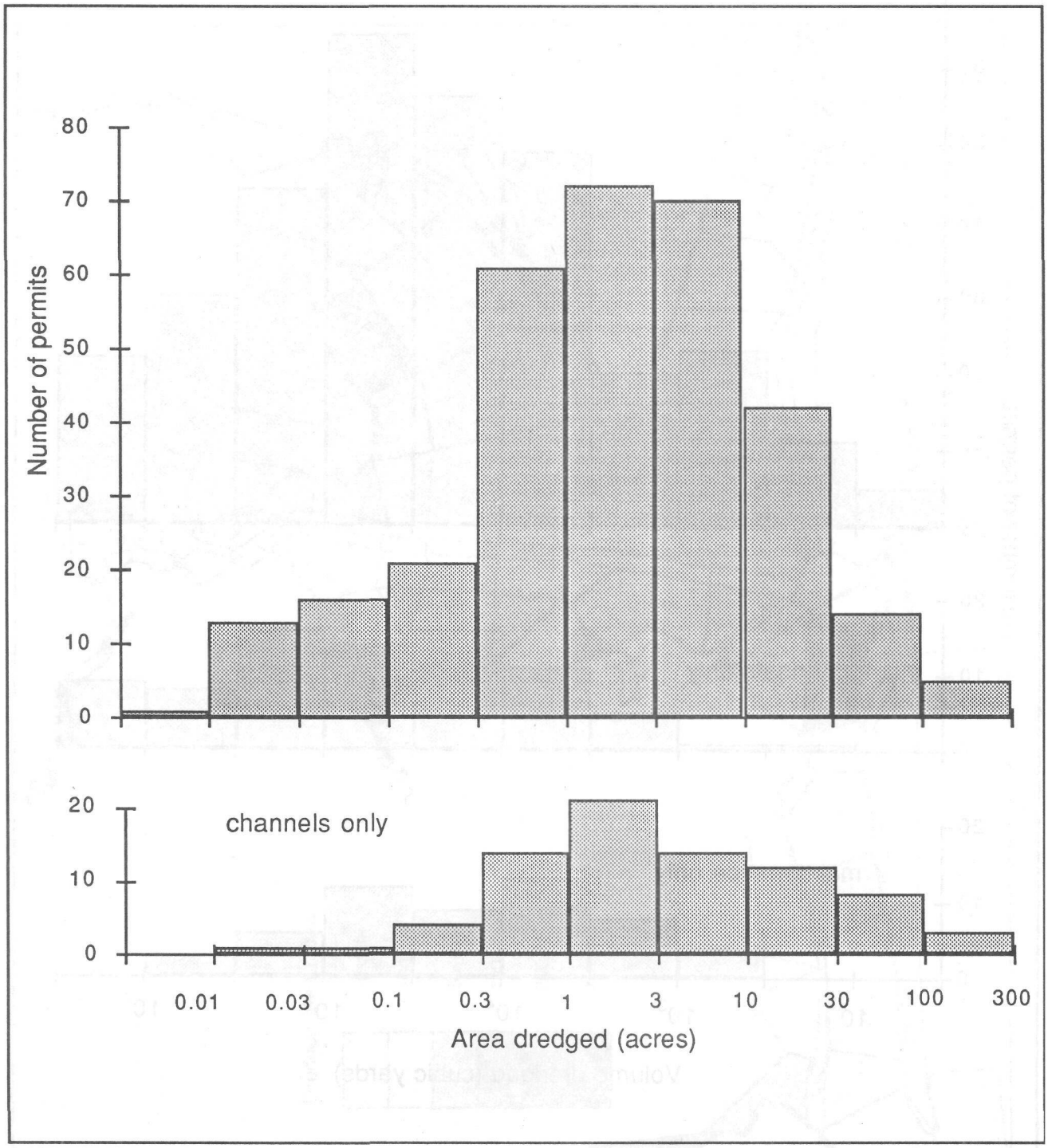


Figure 4-20. Frequency of permits by project scale as area dredged

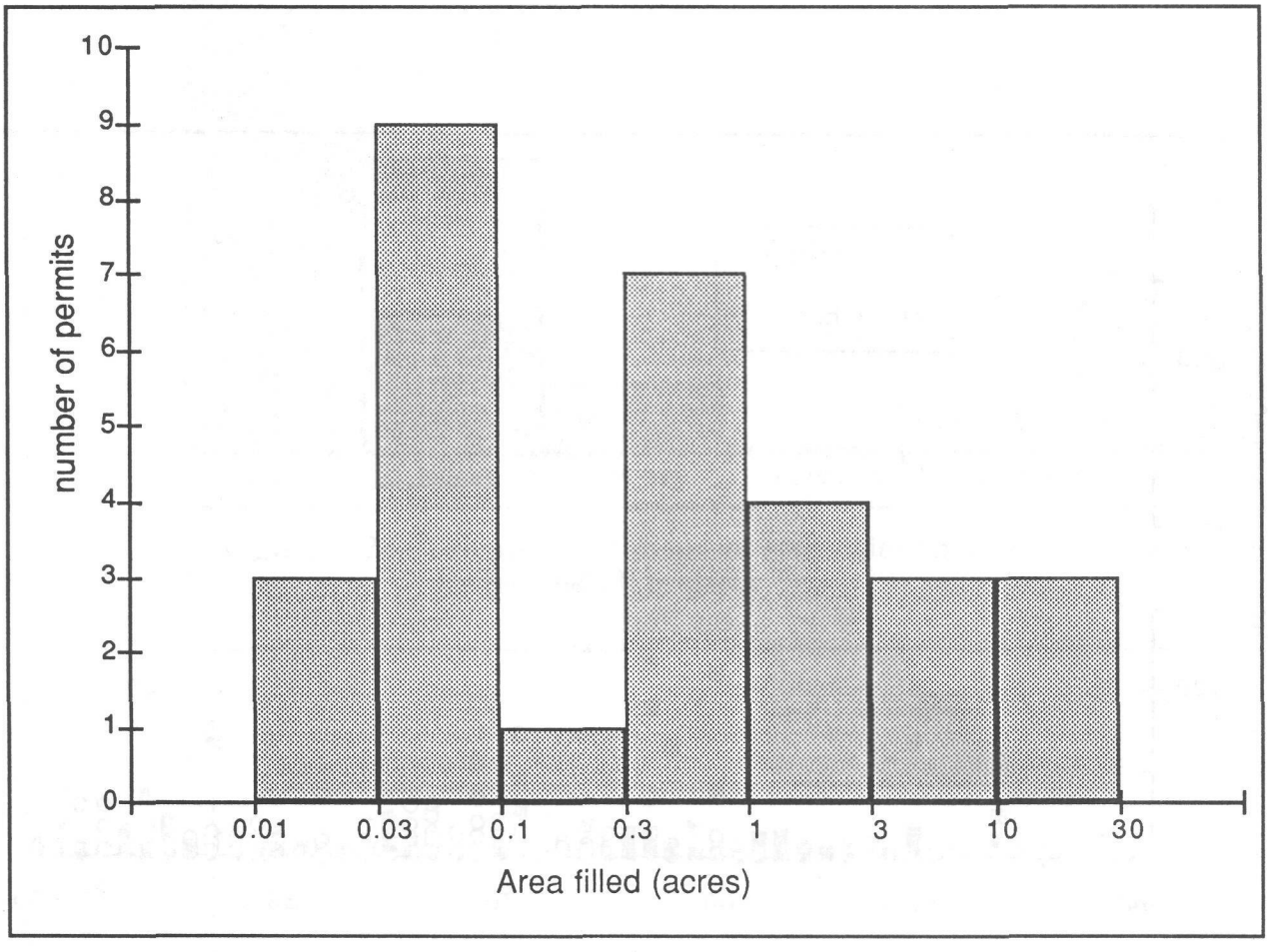


Figure 4-21. Frequency of permits by project scale as area filled

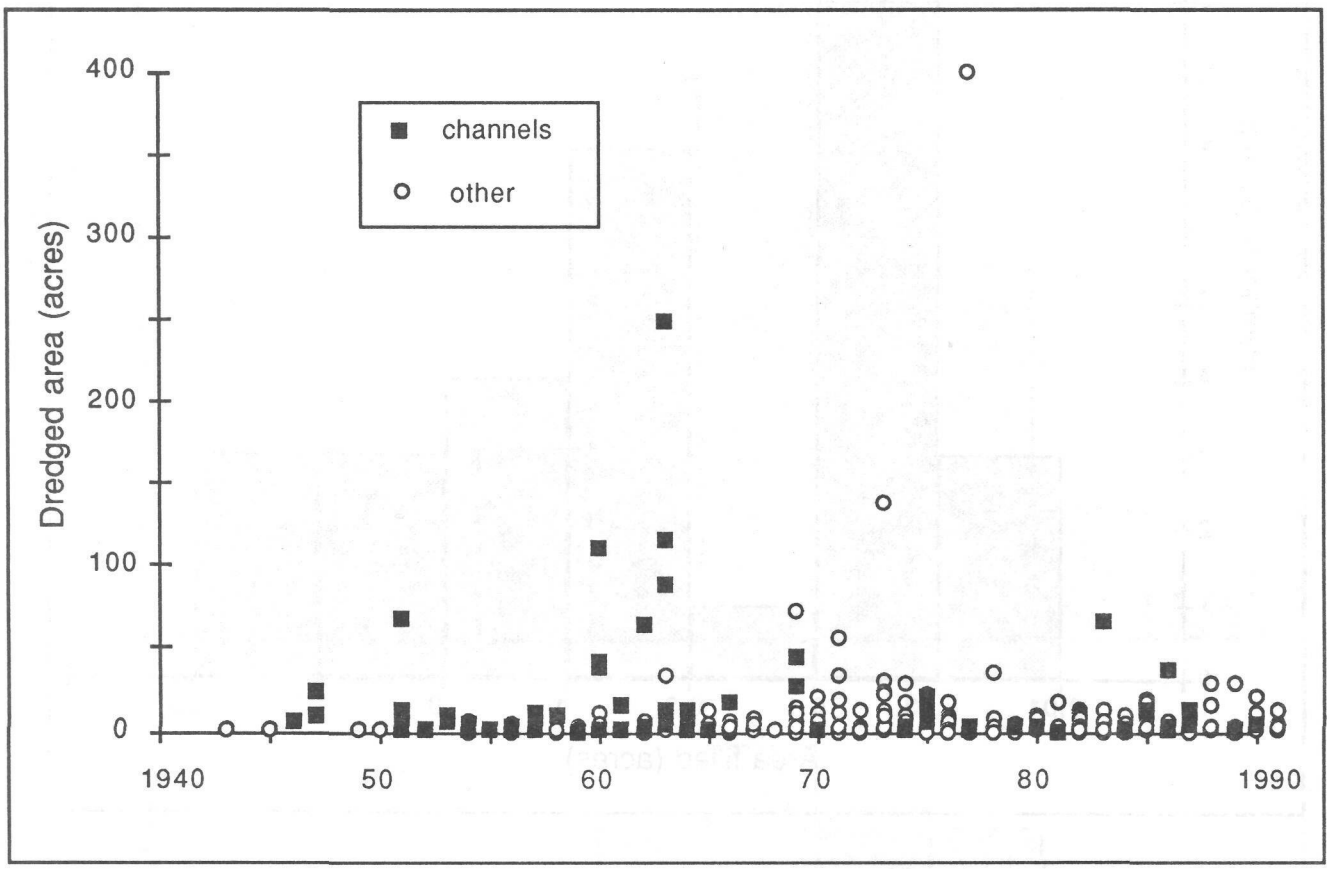


Figure 4-22. Project scale as dredged area versus time

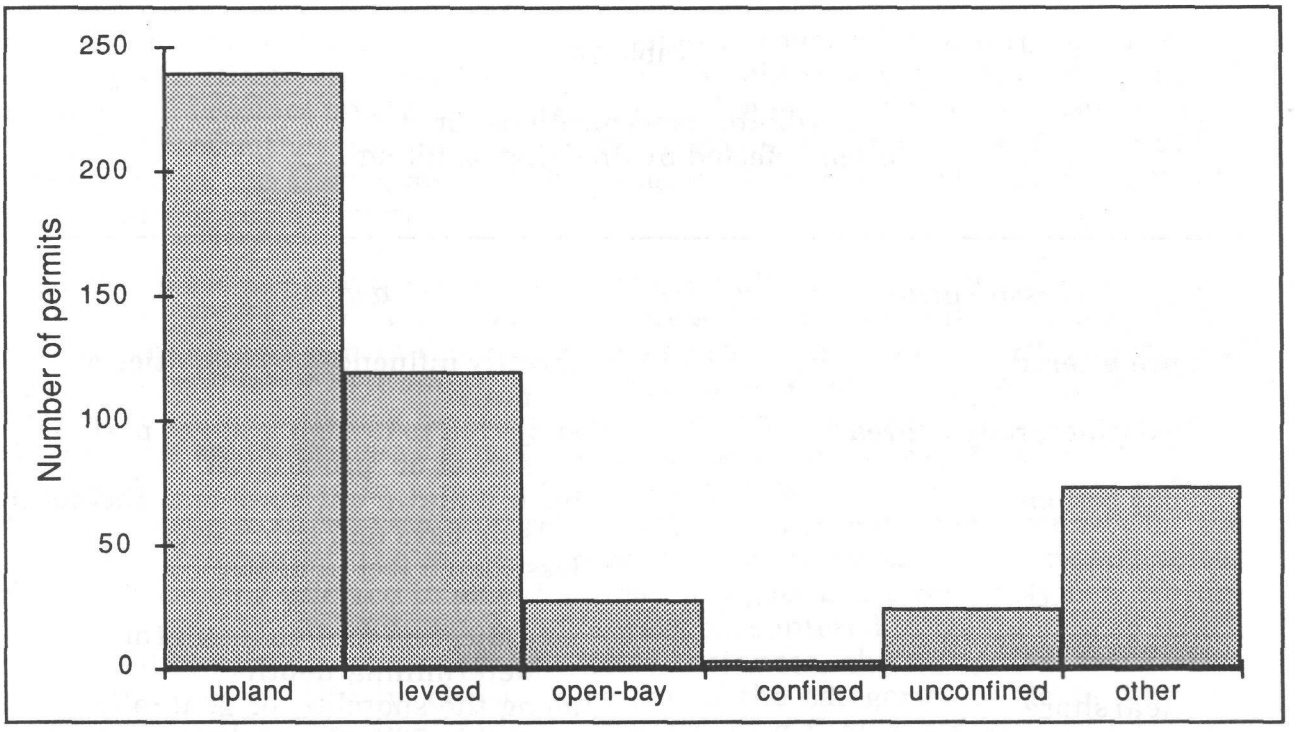


Figure 4-23. Frequency of disposal strategies (nonexclusive) in dredge and fill projects

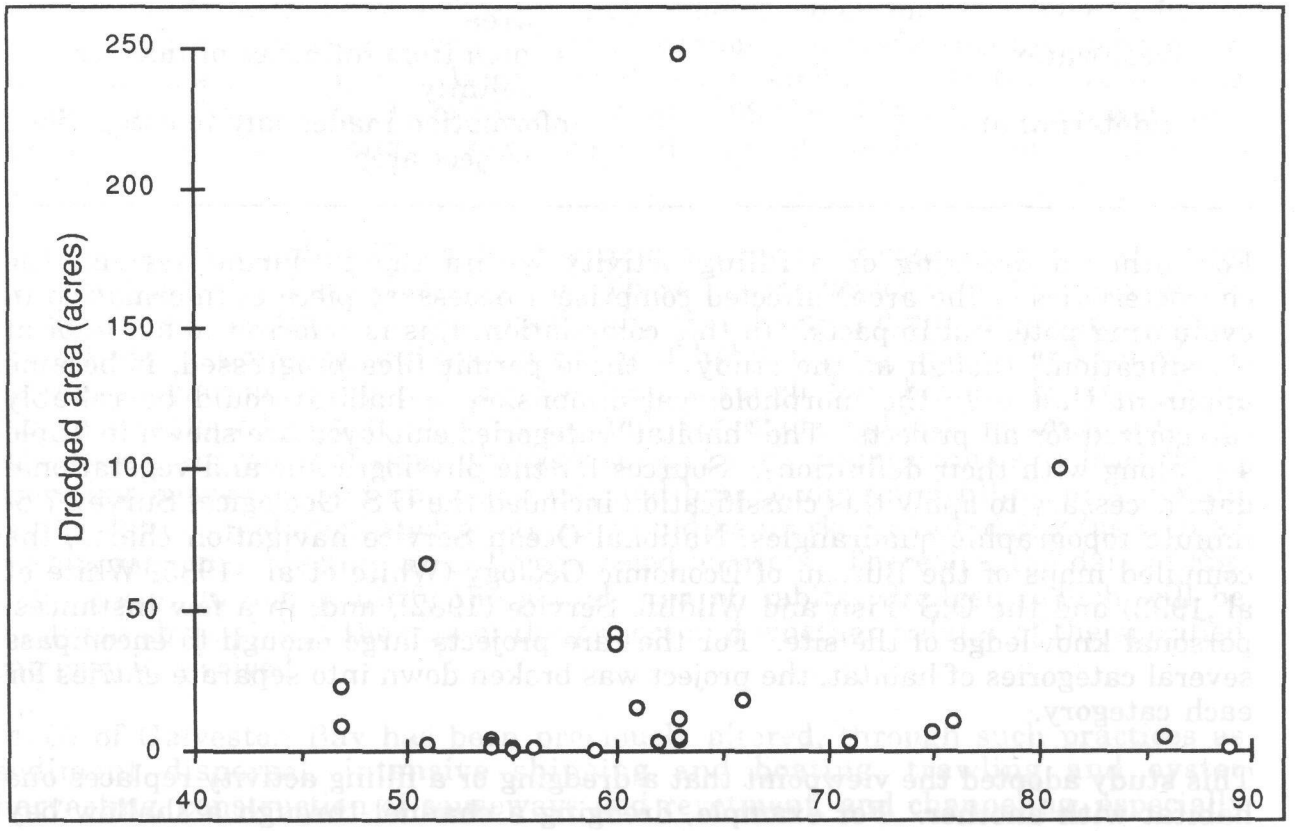


Figure 4-24. Project scale using open-bay disposal, as dredged area versus time

Table 4-6

Habitat classifications for
areas affected by dredging or filling

classification	*definition*
pre-altered	directly influenced by activities of man
existing dredged area	subjected to dredging in the past, a subset of "pre-altered"
bay bottom	open aquatic environment, including side bays and tributaries
shallow	less than 5 feet in depth
unknown depth	no indication and no means of determining depth
nearshore	along the shoreline or generally within 50-100 ft of shore
marsh	occasionally or regularly inundated, and vegetated
oyster reef	submerged or emergent oyster reef area
freshwater	isolated from influence of tides or salinity
indeterminate	information inadequate to categorize project area

For either a dredging or a filling activity within the estuarine system, the characteristics of the areas affected comprise a necessary piece of information in evaluating potential impacts. In this compilation, this is referred to as "habitat classification," though as the study of these permit files progressed, it became apparent that only the morphological dimension of habitat could be reliably categorized for all projects. The "habitat" categories employed are shown in Table 4-6, along with their definitions. Sources for the physiographic and vegetational data necessary to apply this classification included the U.S. Geological Survey 7.5-minute topographic quadrangles, National Ocean Service navigation charts, the compiled maps of the Bureau of Economic Geology (White et al., 1985, White et al.,1992) and the U.S. Fish and Wildlife Service (1982), and, in a few instances, personal knowledge of the site. For the rare projects large enough to encompass several categories of habitat, the project was broken down into separate entries for each category.

This study adopted the viewpoint that a dredging or a filling activity replaces one habitat with another. For example, dredging a channel through a shallow bay

replaces shallow bay habitat with non-shallow. Disposal of the material in the open-bay can effectively replace bay habitat with shallow-water, or even upland, if the material becomes emergent. We offer no judgment in the present context as to the quality of either the displaced or the replaced habitat or their relative importance in the Galveston Bay environment, but merely compile data on the magnitudes of replacement.

Of course, such a "habitat replacement" is generally not *per se* an objective of the permitted project. In a few rare instances, a project will include habitat replacement in addition to the permitted project work for the specific purpose of creating some form of habitat considered more ecologically desirable. This includes such activities as creation of an emergent island to serve as a rookery, spreading of shells to act as cultch, transferring an oyster reef to a new location, or sprigging cordgrass in a newly created intertidal flat. This type of habitat development is included as a requirement of the 404 permit to compensate for the perceived damage of the project work to the ecosystem, the new habitat replacement being referred to as *mitigation*. Mitigation is a relatively new feature of the 404 process, and only ten permits were encountered in this review in which formal mitigation was included. In these instances, the mitigated areas were determined quantitatively, classified in one of the categories of Table 4-6, and made a separate entry in the data. (Considering that mitigation has become integral to the 404 permitting process within the last decade, it is somewhat surprising that so few permits with mitigation were encountered. The most probable explanations are that the subsample was restricted to dredge or fill activities only, within the estuarine environment, which may not have required compensatory mitigation, or that documentation of specific required mitigation was inadequate or absent. While not directly comparable to this study, it is noteworthy that the study of Sifneos et al., 1992, of 404 freshwater wetlands permitting in Texas and Arkansas found only 46 usable permits involving mitigation.)

Figures 4-25 through 4-27 display the time history of dredging projects affecting various types of habitat classification. These figures depict characteristics of the *dredged* area (not the area of disposal), and give the area dredged as a measure of project size. Most projects span a range of habitat categories. For example, a permitted channel may include dredging through bay bottom habitat, then through shallow bay bottom, then through nearshore habitat. A marina might include an approach channel through several such aquatic zones, a boat basin spanning nearshore and upland areas, and bulkheading and filling in a marsh. In the data compilation, such a project would be marked as dredging (as well as channeling, etc.) affecting all of these named habitats. Therefore, the data of Fig. 4-25 *et seq.* do not quantify the actual area of habitat dredged (which will be analyzed shortly), but the size of the project and whether habitat of the specified category is involved.

Much of Galveston Bay has been previously altered, through such practices as sediment dispersal, intensive shipping and boating, trawling and oyster harvesting, construction of causeways and revetment, and channeling, especially

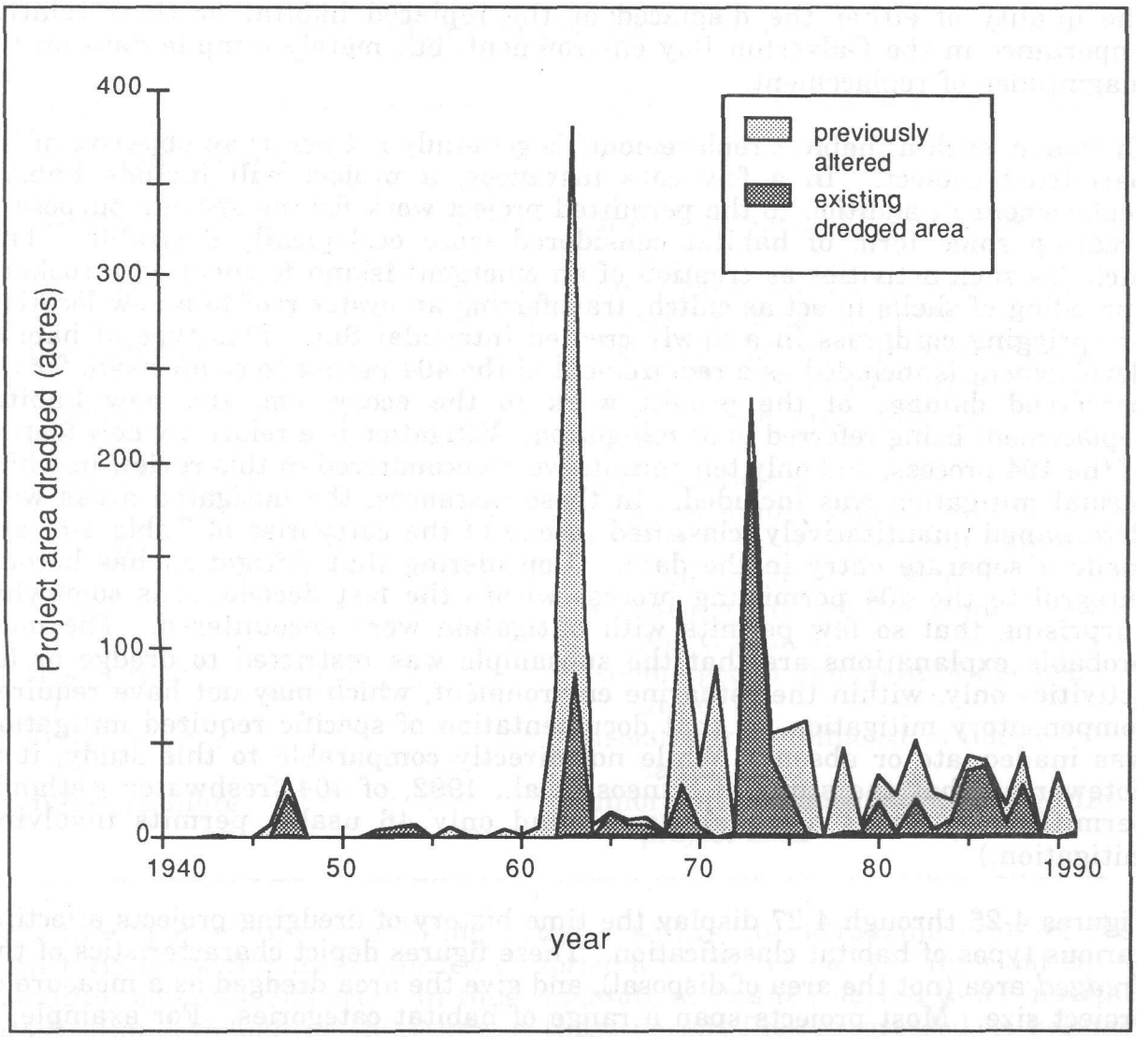


Figure 4-25. Project scale by dredged area, affecting previously altered regions

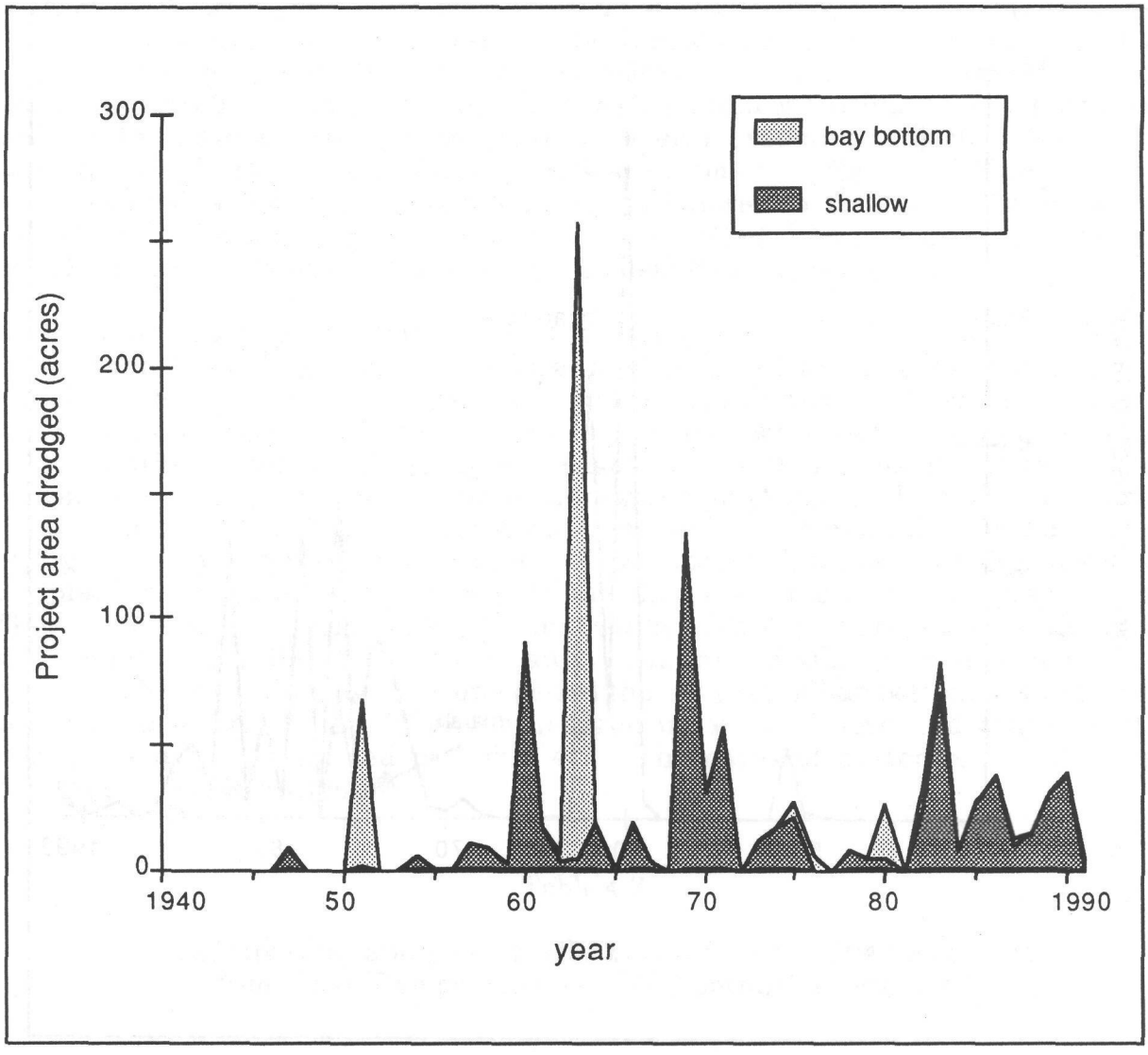


Figure 4-26. Project scale by dredged area, affecting aquatic regions

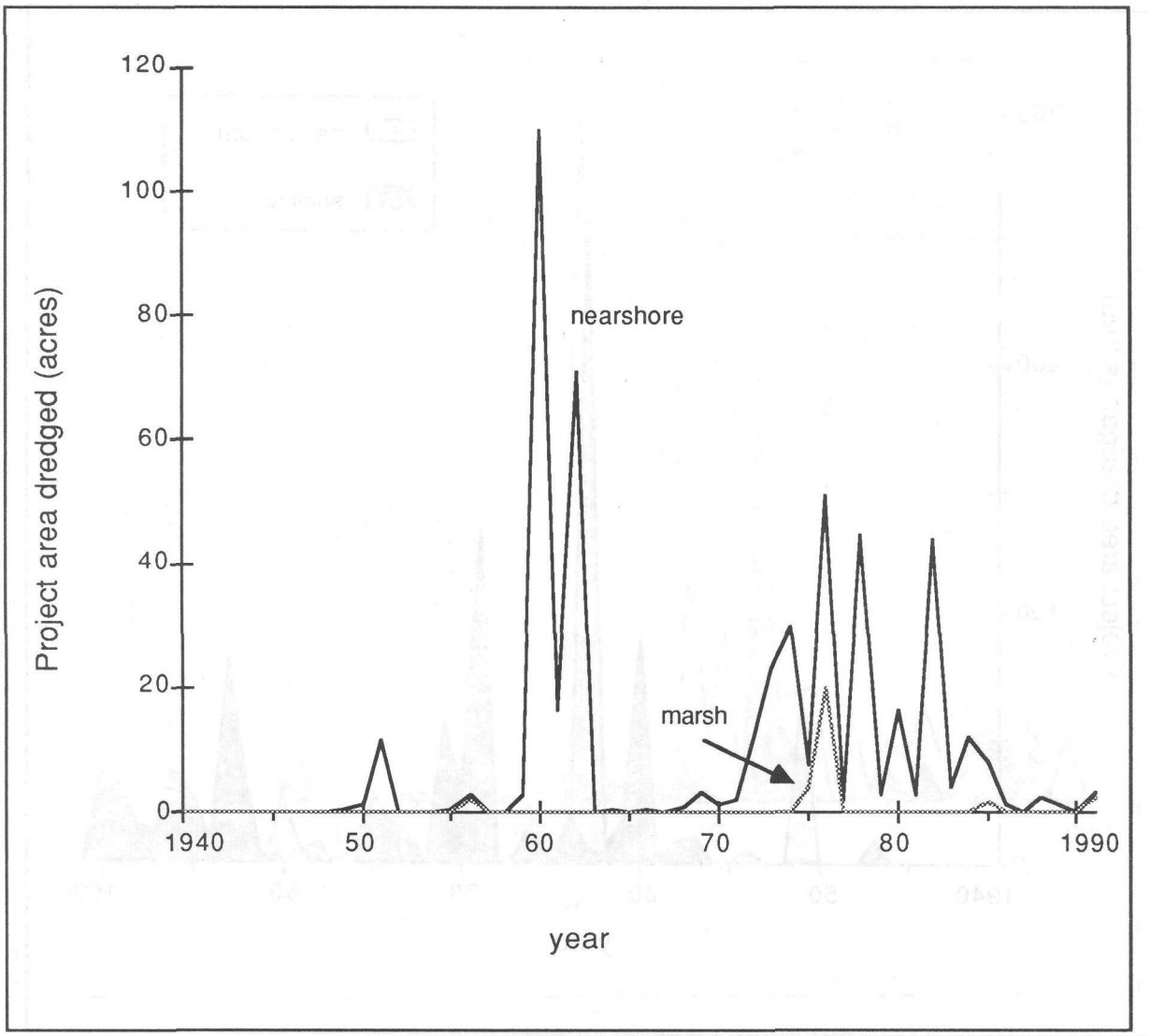


Figure 4-27. Project scale by dredged area, affecting nearshore & marsh

in proximity to concentrations of man's activities. The area between Texas City Dike and the Galveston causeways is an excellent instance of a "previously altered" environment. As might be expected, a significant proportion of 404-permitted activities is situated in such regions. The annual dredged area since 1940 of permits in previously altered areas is shown in Fig. 4-25. The subset of these activities specifically in previously dredged areas is indicated. Fig. 4-26 displays dredging activities in open aquatic areas, with the subset in shallow areas indicated. This figure emphasizes the concentration of 404-permitted activity in shallow areas, in contrast to federal dredging projects. Nearshore areas are similarly affected by 404 activities, as shown in Fig. 4-27. Marsh habitat is considered a separate category from nearshore, so this is not a subset of nearshore. The number and scale of 404-permitted dredging projects affecting marsh are minor compared to those in the nearshore zone.

In order to quantify the influence of 404-permitted activity on specific habitats, each of the Pass Two projects was examined in detail to apportion the dredging and filling activity by habitat category, and to determine specific areas associated with each. Volumes of dredge-and-fill material were not computed for this determination, since the meaningful measure is the *area* of habitat involved, not its volume. Due to the screening of nonestuarine projects, the only freshwater habitat encountered in this data set was that behind existing levees or barriers, a negligible amount for present purposes. Bay bottom habitat is created by dredging of upland areas (especially adjacent to the shoreline) and of shallow bay bottom. There has been a cumulative loss of shallow bay bottom--represented in this data set sample--since 1940 of 844 acs, and a similar cumulative loss of nearshore habitat of 333 acs. During the same period the net gain of bay bottom habitat totals 488 acs, including 28 acs of newly dredged uplands. These and other habitat categories are summarized in Table 4-7. The gains of oyster reef and marsh habitat are due to mitigation.

Table 4-7

Cumulative loss and gain of habitat categories in 1940-91 period from Pass Two subsample of 404-permitted projects

Habitat category (Table 4-6)	Loss (acres)	Gain (acres)
pre-altered	46	488
existing dredged area	100	488
bay bottom	177	488
shallow	844	1
nearshore	333	0
marsh	3293	1
oyster reef	5.8	85